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STREAM POLLUTION BY COAL MINE DRAINAGE,
UPPER OHIO RIVER BASIN

Federal Water Pollution Control Administration
Wheeling, West Virginia

March 1968

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STREAM POLLUTION BY COAL MINE DRAINAGE

UPPER OHIO RIVER BASIN

Work Document No. 21

This document has been prepared to record a specific water pollution control activity carried out to date in furtherance of the water pollution control program being developed in the Ohio River Basin. The information contained herein will serve as a ready reference to aid in the planning and development of the program in the Basin, for appropriate in-service training of participating personnel, and facilitating program activities with other cooperating groups.

Questions or comments relative to this material should be directed to:

Mine Drainage Unit
Planning and Evaluation Section
Wheeling Field Station

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION

March 1968

Details of illustrations in
this document may be better
studied on microfiche.

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PURPOSE AND SCOPE

The Ohio River Basin Project of the Federal Water Pollution Control Administration is engaged in studies directed toward the determination of the extent of the mine drainage stream pollution problem. Considerable effort will be needed to describe the sources and amounts of mine drainage and to ultimately recommend a remedial program. This document was prepared as a Wheeling Field Station work document to evaluate present and future conditions based on existing knowledge.

Section 206 of the Appalachian Regional Development Act of 1965, PL 89-4, directs the Secretary of the Army to prepare a comprehensive plan for the development and efficient utilization of the water and related resources of the Appalachian region. Several Federal agencies, including the Federal Water Pollution Control Administration, were directed to assist the Secretary of the Army in the preparation of the plan and report entitled "Report for development of water resources in Appalachia".

As a major part of the water resources survey and plan, the Federal Water Pollution Control Administration was requested to provide information that would describe the mine drainage stream problem in Appalachia, its location and magnitude, measures for the alleviation and eventual control of mine drainage pollution, and a preliminary cost estimate of remedial measures. This document was prepared to provide the requested information in the upper Ohio River Basin for volume XXIX, Appendix R, Attachment A, entitled "Stream pollution by coal mine drainage in Appalachia".

All conclusions, recommendations, and preliminary estimates contained in this document are subject to further refinement as the program of the Ohio River Basin Project progresses.

ACKNOWLEDGMENTS

The authors express appreciation for the cooperation and assistance of the following State and Federal agencies who supplied general information concerning areas where streams are polluted by mine drainage:

West Virginia Department of Natural Resources

Pennsylvania Department of Health

Ohio Department of Natural Resources

Kentucky Water Pollution Control Commission

Virginia State Water Control Board

Maryland Department of Water Resources

U. S. Department of Agriculture, Soil Conservation Service



SUMMARY

The drainage from bituminous coal mines has been a longstanding water pollution problem in the Appalachian coal fields and continues relatively unabated at the present time. Water quality of streams receiving mine drainage is seriously altered and the streams are frequently rendered unfit for many legitimate water uses. Acid mine water is associated with both active and abandoned mining operations. The drainage from the abandoned sites represents that portion of the problem which will be the most difficult to abate. It is conservatively estimated that damages from mine drainage pollution in the upper Ohio River Basin exceed 10 million dollars annually. These damages are projected to reach 28 million dollars annually by the year 2020 unless corrective measures are taken.

It is estimated that an overall reduction of 80 percent of the acid mine drainage load can be effected through regulatory control measures for active operations and a physical abatement program for inactive operations. A preliminary cost estimate of \$850.8 million is placed on the physical abatement measures required to achieve the anticipated residual pollution load for the upper Ohio River Basin, (Table 27).

Some degree of mine drainage pollution exists in each of the minor basin drainage units of the study area (Figure 1). The problem is particularly severe in the Allegheny and Monongahela watersheds, and small tributaries to the Ohio River. Conditions in each drainage unit are summarized below:

Allegheny River basin

About 60 percent of the land area of the basin contains coal reserves and is affected to some degree by mine drainage. Survey results show that over 1,000 miles of streams are affected, primarily in Armstrong, Cambria, Clarion, Indiana, Somerset, and Westmoreland Counties. The principal tributary drainages affected are portions of the Clarion River basin and virtually all of the Kiskiminetas River basin. Twenty streams were found to be discharging more than five tons per day of acid each. The major acid streams in the basin are the Clarion and Kiskiminetas Rivers which discharged average net acid loads of 60 and 494 tons per day, respectively, during the 1966 water quality survey.

It is estimated that there are 1,600 tons per day of acidity discharged to the streams of this watershed from active and abandoned mining operations. It is projected that increased mining activity will raise this load to 4,100 tons per day by the year 2020, assuming no corrective measures.

Monongahela River basin

The Monongahela River basin is the most intensely polluted by mine drainage of all the minor basins of the upper Ohio River Basin. Coal reserves are present in about 85 percent of the basin, and production remains high. More than 1,600 miles of streams in 17 counties are polluted to varying degrees by mine drainage. The worst conditions exist in Westmoreland, Fayette, and Green Counties, Pennsylvania; and Monongalia, Marion, Harrison, Taylor, Barbour, and Preston Counties, West Virginia. The principal tributary watersheds affected in order of pollution intensity and average net acidity loads discharged during the study period are the Cheat River (204 tons per day), the Youghiogheny River (144 tons per day), and the West Fork River (156 tons per day). The Tygart Valley River, which joins the West Fork River to form the Monongahela, carried an average net acidity of 40 tons per day.

It is estimated that there are 1,200 tons per day of acid discharged to the basin streams from both active and inactive mining operations. This acid load may increase to as much as 2,100 tons per day by the year 2020, if projected increases in mining activity are realized and no pollution abatement measures are taken.

Beaver River basin

Mining activity, recoverable coal reserves, and the principal mine drainage problems of the area, are concentrated in the Pennsylvania portion of the basin. The watershed contains 108 miles of streams affected by mine drainage, 93 of which are in the Slippery Rock Creek drainage of Butler and Lawrence Counties, Pennsylvania. A major fish kill occurred in Slippery Rock Creek in 1964 due to flushout of acid mine water. Minor amounts of mine drainage stream pollution exists in the Mahoning River area of the Beaver basin. The Ohio Counties of the watershed are excluded from the defined Appalachian region.

It is estimated that an acid load of 50 tons per day is discharged to the streams of the Beaver River basin from active and abandoned coal mine sites. Projected mining production is expected to result in the discharge of 250 tons per day of acid by the year 2020, without corrective measures.

Muskingum River basin

About 80 percent of the basin contains coal reserves, and prospects for future mining activities are good. Drainage from coal mining activities has affected some 500 miles of streams in this watershed. However, the principal streams of the basin do not show significant water quality degradation from mine drainage. Among the many smaller streams seriously affected, Moxahala Creek in Perry and Muskingum Counties is probably the most seriously polluted stream in the watershed. Its drainage area contains 90 miles of polluted streams.

An estimated acid load of 400 tons per day is discharged to streams of the Muskingum River basin from active and abandoned mines. Assuming no corrective measures are taken, it is estimated that this load will increase to 1200 tons per day by the year 2020.

Hocking River basin

Eighty percent of current coal production in the basin is by surface mining methods; however, the area has an early history of deep mining which contributes a significant part of the present water pollution. The basin contains some 360 miles of streams polluted by mine drainage, principally in Athens, Hocking, and Perry Counties. Sunday and Monday Creeks are the most seriously affected tributary watersheds to the Hocking River. Sunday and Monday Creeks discharged average net acid loads of 13 and 19 tons per day, respectively, during the 1966 water quality survey.

An estimated acid load of 200 tons per day is discharged to the basin streams from all sources. It is projected that increased mining activity will raise this load to 990 tons per day by the year 2020 unless corrective measures are applied.

Little Kanawha River basin

About 60 percent of the basin is underlain by coal reserves; however, the resource has not been extensively developed. Thirty miles of streams in the area above Glenville, West Virginia, are affected by mine drainage. This mileage is comprised by a few small tributaries that enter the main stream in the reach from the Gilmer-Braxton County line downstream to Glenville. Although mine drainage pollution is not serious in this basin at the present time, sufficient coal reserves exist for potentially serious problems to develop.

It is estimated that an acid load of 10 tons per day is discharged to streams of the basin from all sources. Further development of coal reserves of the basin is projected to raise the acid loading to an estimated 130 tons per day if corrective measures are not taken.

Kanawha River basin

The Kanawha basin contains an estimated recoverable coal reserve of 23 billion tons, and it has been a major coal-producing region for a very long time. Significant mine drainage pollution occurs in the Pocatalico, Coal, Elk, and New River watersheds. Generally, serious pollution conditions exist in the headwater areas of these drainages and in small tributaries of these streams. Pollution in the main streams of the basin is intermittent, and their water quality is not severely degraded. Much of the mine water in this area of the State of West Virginia is alkaline rather than acid in character and is used for public water supply by a number of small communities. Fourteen hundred miles of streams are affected to some degree by mine drainage in the Kanawha River basin.

An estimated acid load of 350 tons per day is discharged to streams in this watershed from all coal mining sources. This load is projected to increase to 560 tons per day by the year 2020, assuming no corrective measures are taken.

Scioto River basin

A very small portion of this drainage area is underlain by coal deposits. Only parts of two counties in the lower end of the basin are involved in coal mining activity and the amount of mine drainage present is small. About eight miles of streams are affected by mine drainage in this watershed. Because of the small area involved, stream pollution by mine drainage will not become a problem except on a very localized scale.

An acid load of 10 tons per day is estimated to be discharged at the present time, and this load is projected to increase to 80 tons per day by the year 2020.

Guyandotte River basin

The production of coal and its support industries are the principal economic activities of this mountainous area. Many tributary streams in the headwaters areas of the basin are polluted by mine drainage but the main-stem is not seriously affected. Acid mine drainage is not as much of a problem in this region as in the basins to the north. Mine drainage effects in the Guyandotte drainage are principally in total mineralization added to the streams and sulfate, hardness, iron, and manganese concentration levels. The intermittent presence of silt and fine coal in the streams is also a significant problem.

It is estimated that an acid load of 100 tons per day is discharged to the basin's streams at the present time. A projected acid load of 130 tons per day is expected due to coal industry expansion by the year 2020, assuming no corrective measures are taken.

Big Sandy River basin

Coal production is the major industry in the basin and there were more than 2,800 active mines in 1965. Most of these mines were underground operations. Many streams in the headwaters of the basin are affected by mine drainage. Serious water quality problems are intermittently caused by the entry of fine coal and silt from the mining areas into the streams. The drainage area above Fishtrap Reservoir on Levisa Fork is of particular concern with respect to the occurrence of silt and fine coal in the streams. Five hundred miles of streams are affected by mine drainage in the Big Sandy basin.

Although acid pollution is not a major problem in the basin, the total mineralization from mine drainage contributes to high iron, sulfate, and hardness concentrations in receiving streams. An estimated acid load of 300 tons per day is discharged to the streams from all sources. This loading is projected to increase to 370 tons per day by the year 2020, assuming no corrective measures.

Ohio River main stem - minor tributary basins

The Ohio River receives significant amounts of mine drainage along both its banks from small tributary watersheds draining from Pennsylvania, Ohio, and West Virginia. Recent stream studies have measured an average net acid load of over 150 tons per day discharged to the Ohio River from the affected tributaries. A total of over 1,300 miles of

affected streams are present in this drainage area. The majority of the measured acid loading and the miles of affected streams are in the State of Ohio. The largest and most significant stream in the minor tributary classification is Raccoon Creek, Ohio, which enters the Ohio River below Gallipolis. This stream carried an acid load of 110 tons per day during the survey period.

An estimated acid load of 1,000 tons per day is received by the streams of this defined drainage area. This load is projected to increase to 4,000 tons per day by the year 2020, assuming no corrective measures.

INTRODUCTION

Acid mine waters result from the mining of ores of various metals and from deposits of anthracite and bituminous coals. In parts of Missouri, Kansas, and Oklahoma, lead and zinc mining produces acid mine drainage; in Arkansas the extraction of barite and manganese ores creates an acid drainage problem; and the mining of gold and other ores in South Dakota and Montana creates a similar problem.

The major acid drainage problems, however, are in the anthracite and bituminous coal mining regions of the country. The problem is particularly acute in association with bituminous coals because of the extensive deposits of this resource and its broad utilization as a mineral fuel. Bituminous coal is so plentiful in this country that it is mined in 33 states. The major coal fields are the Appalachian field of the eastern states, the Interior fields of the mid-continent states, and the Rocky Mountain field of the western states. Of these major fields, the Appalachian field yields about 70 percent of the bituminous coal production of the United States. It contains the highest-grade coals of the country and the largest continuous bituminous area in the world. The field is about 70,000 square miles in area and embraces the coal areas of Pennsylvania, West Virginia, Ohio, Maryland, Virginia, Kentucky, Tennessee, Alabama, and Georgia.

The acid mine drainage problem resulting from bituminous coal mining is primarily located east of the Mississippi River and largely in the Appalachian coal field whose principal drainage is the Ohio River and its tributaries. The acid drainage problem stemming from bituminous coal mining is generally recognized as the most widespread pollution problem in the Ohio River basin. The coal fields of the Ohio River basin are shown in Figure 2.

The water pollution problem associated with coal mines is not a new one - it has existed since the opening of the first mines in the Ohio River basin prior to 1800. Although these mines have long since been abandoned, some of them still produce acid drainage. From a small beginning over 150 years ago, coal production has grown with progressive industrialization of the country, and along with the development of the coal industry has grown the mine acid pollution problem. It is ironic that the coal-mining industry is in large part responsible for the area's prosperity and at the same time seriously damages that area by its drainage.

It has been stated that if one were to outline on a map the economically depressed Appalachian region, one would likewise, in large part, be outlining the area of serious acid mine drainage pollution in the eastern United States. The causes of economic illness of an area are not so simple that they can be related to one single factor; however, there is undoubtedly a substantial measure of cause and effect to be found between mine acid pollution and depression in the region.

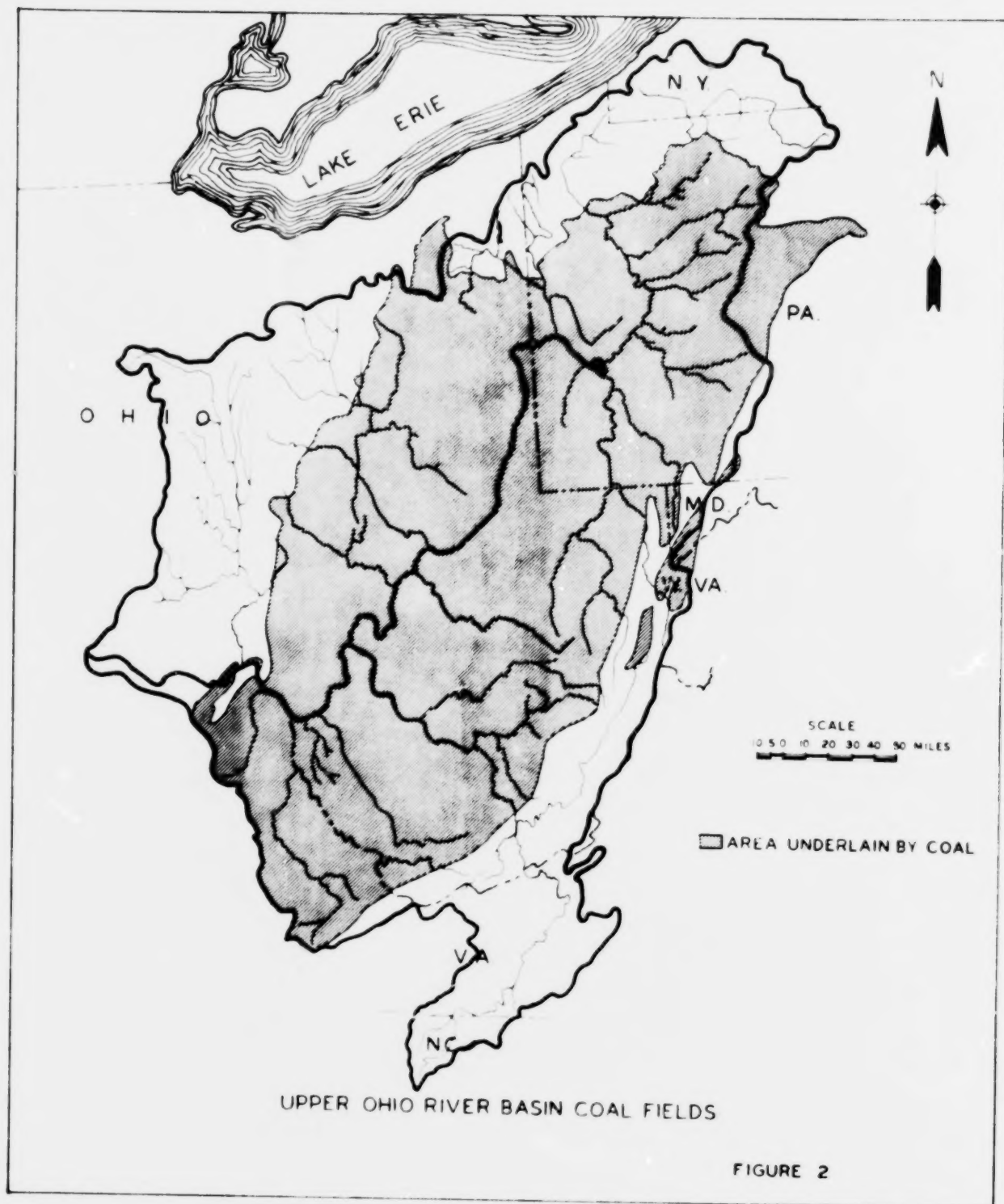


FIGURE 2

HISTORY OF PROBLEM

Although evidence of the magnitude and extent of water pollution during the early years of coal mining is meager, a number of written references to the problem were made prior to 1900. Some of the earliest recorded references to the acid condition of certain streams in the coal mining areas were made by the communities and industries which utilized such streams for water supply. The U.S. Geological Survey in a 1906 publication described the quality of waters used for public supply in the upper Ohio River Basin, pointing out those waters contaminated by mine drainage. (7).

The Youghiogheny River contained sufficient free acid at times of low flow to kill fish as early as 1890; however, the stream has been substantially improved in recent times through state and industry efforts. In 1905, a large number of fish were killed in the Allegheny River below the Kiskiminetas River as a result of acid mine drainage from the Kiskiminetas River and its tributaries. (7).

During the period 1913 to 1916, the U. S. Public Health Service conducted perhaps the first recorded survey of the effects of acid mine drainage in this country. (8). The report of this survey cited the deleterious effects of acid pollution in areas of the upper Ohio River Basin. The document concluded that mine drainage was responsible for a major portion of the acid pollution, and that this source of pollution might be reasonably expected to increase.

In tracing recognition and description of the acid drainage problem in the early days of coal mining in this country, it is pertinent to cite a court test whose outcome recognized the problem, and in this case, the injustice of it. It is known as the Indian Creek Pollution Suit.

The case was that of a private water company serving municipalities in southwestern Pennsylvania, whose water supply reservoir was in imminent danger from upstream coal mining discharges. In 1922, the water company asked the courts for an injunction to prevent the discharge of mine waters which would be carried into their reservoir. The Fayette County Court refused to grant an injunction; however, the Pennsylvania Supreme Court reversed the lower court decision. The reversal opinion, which was concurred in by the U. S. Supreme Court, states:

"It is controlled by one fact and a single equitable principle; the fact that the stream has been polluted, and the principle that this creates an enjoined nuisance if the public uses the water."

In 1923 a paper was published which pointed up the awareness and concern over the problem in certain quarters. The paper stated (9).

"It is becoming very apparent that the sources of pure water supply in the coal regions are being rapidly destroyed by the drainage from coal mines, and that very few streams in their pristine purity are now available. Furthermore, although the drainage from coal mines may not be considered as strictly prejudicial to public health, yet it must be admitted that any water supply receiving such drainage must finally be rendered unfit for either domestic or industrial use; the time required to accomplish its destruction being dependent upon the character and amount of mine drainage, and the neutralizing capacity of the natural waters. Many streams which a few years ago were admirable sources for water supplies are now running red with drainage from coal mines, and this value for either domestic or industrial use is completely destroyed."

By the early 1930's the problem had grown to such magnitude and had attained sufficient concern that the Federal Government authorized a program of sealing worked-out coal mines to prevent acid formation. This program, commenced in 1933, was based on earlier experimental work performed by the U. S. Bureau of Mines that showed a reduction in acid production from sealed mines. The program was cooperatively conducted by a number of Federal and State agencies from 1933 to 1941, and supervised and administered by the U. S. Public Health Service. The program was active in coal producing areas of nine states which contribute drainage to the Ohio River system (Alabama, Illinois, Indiana, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee and West Virginia).

Although conducted as a relief measure, a substantial amount of sealing was completed and an impressive initial reduction in stream pollution reported. For example, after three years of sealing operations in West Virginia, it was reported that 3,644 mine openings had been sealed. The records indicated that over 500 miles of streams had been greatly improved by this sealing in West Virginia. (10).

The 1943 report of the U. S. Public Health Service concerning pollution of the Ohio River summarized the activities and results of the mine sealing program. It was reported in this document that an overall 28 percent reduction in mine acid load had been achieved to 1940 as a result of the mine sealing program. The report estimated that a 70 to 80 percent reduction in acid load could be expected four to five years after completion of the program. However, the needs of the Nation at the outbreak of World War II saw the abandonment of the program and the loss of opportunity for subsequent evaluation of the sealing method as an abatement technique. Many of the sealed mines were put back in production during the war and no maintenance was provided for the undisturbed seals so that much of whatever benefit was achieved has been lost.

It was estimated that more than 1.8 million tons of acid per year were discharged into the streams of the upper Ohio River Basin prior to the mine sealing program of the 1930's (6). Table 1 presents this original acid load, in tons per year, for the minor basins composing the upper Ohio River Basin. Other regional acid production and acid loading estimates have been made but the magnitude of the total problem has never been quantitatively measured. The water pollution control program of the Wheeling Field Station includes the objective of physically measuring pollution magnitudes in the upper Ohio River Basin.

In the period since the high-production war years to the present time, research activities, self-regulation by the industry, and legislative control have increased at a rapid rate. In 1948, the first Federal water pollution control act was passed which led to the current Federal Water Pollution Control Act, Public Law 660, as amended. Although three states (Ohio, Pennsylvania, and West Virginia) had laws specifically exempting mine drainage from regulatory control prior to the 1940's, varying degrees of legislative control of the problem have been instituted in all the coal-mining states and pressure is ever increasing for more strict regulation and control at all levels.

Table 1

Acid mine drainage, upper Ohio River Basin (6)

<u>Drainage Basin</u>	<u>Original Acid Load, (approx. 1930) CaCO₃ Equivalent, Tons per Year</u>
Allegheny River except Kiskiminetas	83,461
Kiskiminetas River	321,689
Total	405,150
Monongahela River except Youghiogheny	700,972
Youghiogheny River	219,684
Total	920,656
Beaver River	17,388
Muskingum and Hocking Rivers	215,800
Little Kanawha River	818
Kanawha River	32,855
Guyandotte River	20,184
Big Sandy River	60,932
Scioto River	24,100
Minor Tributary Basins to Ohio River	
Pennsylvania	49,397
Ohio	113,500
West Virginia	26,807
Kentucky	-- --
GRAND TOTAL	1,887,587

In the early 1960's, the Division of Water Supply and Pollution Control of the U. S. Public Health Service initiated a program to develop comprehensive plans for eliminating or reducing the pollution of interstate waters on a basin-wide basis. In July 1962, the Ohio River Basin Water Pollution Control Project was established (now in the Federal Water Pollution Control Administration, U. S. Department of the Interior). A field station was established at Wheeling, West Virginia, to study the upper portion of the Ohio River basin. Field activity and studies directed toward determination of the extent of the acid problem, as well as other pollution problems, and ultimate recommendation of a remedial program have been initiated.

DAMAGES

TANGIBLE

Many economic limitations are imposed upon the value of waters whose quality is seriously affected by coal mine drainage. The municipal, industrial, and recreational usage of such waters is impaired throughout the Appalachian coal fields and direct dollar damages are attributable to the pollution of waters by mine drainage. These tangible damages include damages to:

1. Municipal and industrial water supplies;
2. Structures and navigation equipment;
3. Sport fisheries.

These damages are real and may be evaluated in direct monetary terms.

Water Supply Damages

High concentrations of the minerals commonly contained in mine drainage polluted streams make the water unsuitable for certain uses and expensive to treat when it is used. Treatment costs for public water supplies utilizing affected streams are substantially elevated over normal treatment costs.

The principal damage to public water supplies, insofar as treatment is concerned, is commonly measured by the assumed magnitude of hardness increase. Additional damages from acid conditions are incurred from corrosion of intake facilities and other equipment. Treatment provided for the greater part of public water supplies includes facilities for softening. On the basis of these conditions, the damage is measured by the cost of hardness reduction by treatment to a level not in excess of 150 parts per million.

Damages to industrial water supplies include treatment costs for neutralization and softening. In instances where industrial water is not neutralized, notably for condenser cooling water at power plants, damages are limited to plant equipment. Some additional damages are incurred to intake facilities.

It was estimated in 1963 that the annual damages to municipal and industrial water supplies due to acid conditions of the Monongahela River amount to \$1,374,000. (5) These losses are for water treatment only and do not include damages to intake structures and conveyance facilities, pumps, or the added expense of providing acid-resistant facilities.

Present municipal water usage in the upper Ohio River basin from surface water sources is estimated at 436 million gallons per day. Industrial water usage from all sources is estimated at 8,621 MGD. Water use demands for these categories over the study period are listed below:

	(MGD) <u>Present</u>	(MGD) <u>1980</u>	(MGD) <u>2000</u>	(MGD) <u>2020</u>
Municipal Water Supply:	436	549	695	908
Industrial Water Supply:	8,621(1960)	10,723	14,476	20,854

Although no exact determination of the annual damages to water supplies due to mine drainage pollution is available at this writing, it is conservatively estimated that these current damages range from \$7.0 to \$10.0 million.

Navigation Damages

Acid corrosion causes substantial damages to navigation equipment and structures located on streams made acidic by the addition of coal mine drainage. Corrosion of concrete, as well as metal, is the cause of significant losses to boats, barges, and lock and dam structures in the upper Ohio River basin.

The Monongahela River is the most acid stream maintained for navigation in the study area. In 1962, the U. S. Army Corps of Engineers estimated that the annual damages to boats, barges, and lock and dam structures located on the Monongahela River total \$877,000 (5). Assuming that 90 percent of the total mine drainage damages to boats, barges, and lock and dam structures in the study area occur on the Monongahela River, the total damages for the upper Ohio River basin are estimated at one million dollars.

Sport Fisheries Damages

Streams and lakes which contain quantities of mine drainage have a deleterious effect upon fish and related water life. The toxicity of various mine drainage constituents plus the silt and chemical sediments carried by the drainage commonly kill fish and other aquatic organisms thus eliminating sport fishing as a recreational form in the affected water bodies. Often conditions in streams are such that fish are killed in large numbers in a very short period of time. Such fish kills are the result of gradually deteriorating conditions reaching a critical level, or, of the slugging effect of the sudden addition of large quantities of mine wastes to the stream.

The Senate Committee on National Water Resources has predicted that on the basis of numbers of fishermen, the Ohio River Region will show the greatest decline by 1980 of all the Nation's water resource regions (1). The projections made by the Committee further show that in 1980 only five percent of the total number of sport fishermen will fish Ohio River waters compared to ten percent in 1954. The effect of mine drainage on the area streams contributes heavily to these pessimistic projections.

A survey of streams and impoundments which are adversely affected by mine drainage pollution with respect to fish and wildlife has recently (1965) been completed by the U.S. Fish and Wildlife Service (2). The survey indicated about 3,000 miles of streams and 14,000 acres of impoundments adversely affected by acid mine drainage in the area covered by this report.

Based on the 1960 mean number of angler days (142 days) per stream mile of fishable streams in the Ohio River basin, and the 1960 national average daily expenditure for sport fishing (\$5.775), it is estimated that additional sport fishing use realized from the 3,000 miles of affected streams would provide 2.5 million dollars annually to the area's economy. (3) (4).

The damage estimates discussed are projected over the study period in Table 2.

Table 2

Projection of estimable annual damages

	(Millions) Present	(Millions) 1980	(Millions) 2000	(Millions) 2020
Loss of Sport Fisheries:	\$2.5	\$4.0	\$7.0	\$10.0
Structures and Navigation Equipment Damages:	\$1.0	\$1.4	\$2.2	\$ 3.0
Damages to Municipal & Industrial Water Supplies:	<u>\$7.0-10.0</u>	<u>\$9.0-12.0</u>	<u>\$11.0-15.0</u>	<u>\$15.0-20.0</u>
TOTALS:	\$10.5-13.5	\$14.4-17.4	\$20.2-24.2	\$28.0-33.0

In all probability, intangible damages and tangible damages not directly estimable, equal or exceed those listed.

The damages to structures, navigation equipment, and water supplies as a result of stream pollution by coal mine drainage were estimated for a portion of the Ohio River basin by the U.S. Public Health Service in 1943. Although the methods used to estimate the damages are not directly comparable to the present study, these previous estimates serve to illustrate the general order of magnitude of the increase in damages. For the drainage area above the Ohio, West Virginia, and Pennsylvania state lines, the estimated damages amounted to \$2,071,000 per year in 1940 and were projected to increase to \$3,190,000 by 1960. (6)

INTANGIBLE

Many damages attributable to pollution of waters by mine drainage are intangible and not amenable to direct monetary evaluation. These damages are primarily those to potential water uses and esthetic values including recreation, public health and the general economy of the watershed. These damages, while not directly subject to economic evaluation, are of considerable magnitude. They include:

1. Destruction of biological life in streams and lakes;
2. Water bodies made undesirable for certain recreational uses;

3. Decrease in property values along polluted streams;
4. Unwillingness of certain industries to locate along streams so polluted;
5. Unsuitability of the water for agricultural use;
6. Lack of incentive for sewage pollution abatement in acid streams.

Lack of incentive for sewage pollution abatement in acid streams often exists at the community level. The feeling prevails that it serves no good purpose to clean up a stream if it is still going to be of degraded water quality after sewage pollution abatement. Also, it is commonly believed that the acid in a stream destroys the pollution organisms and makes it bacteriologically safe. It is true that acid in a stream does have an inhibitory or lethal effect upon many sewage bacteria, however, this fact should not be considered as a safeguard to public water supplies taken from that stream. In periods of high flow there may be sufficient alkalinity to neutralize the acid and eliminate any bactericidal effect. This would happen at the same time that accumulated sewage deposits in the stream bottom are being flushed out and the greatest need for a bactericidal effect occurs.

FORMATION OF MINE ACID WATER

CHEMISTRY

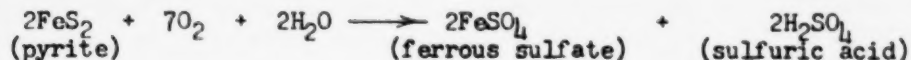
In the mining process, water drains into the mine and must be removed to permit mining to continue and for the safety of the miners. Most water drains into underground mines from ground water storage through the rock intersected by the mine. The mine void serves as a focal point toward which the nearby waters drain. The ground water normally enters the mine over a large area so that its points of entry are difficult to determine. If the mine is located above drainage, the amounts of ground water entering the mine will be smaller, but substantial amounts of surface runoff may find its way into the mine.

As water enters and flows through the mine it may come in contact with sulfur-bearing minerals which have been exposed to the atmosphere by the mining process. When water dissolves and reacts with these minerals it becomes acid in character. This mine water then leaves the mine, either by gravity flow or by being pumped, to enter the nearest water course.

The formation of mine acid is dependent upon the presence of three reactants -- water, oxygen, and sulfur-bearing material.

The sulfur-bearing material is present principally in the form of the minerals pyrite and marcasite. These minerals are both iron disulfide, FeS_2 , but differ in their crystalline structure. Both minerals are often referred to as "pyrites". These pyrites are contained within the coal seams in bony or shaly materials and in the shale and sandstone strata which are commonly adjacent to coal beds. The disulfide is quite variable in its physical form. It is frequently present as minute particles disseminated throughout the rock, and at other times it is present as crystals and crystal aggregates of large size.

During coal mining, iron sulfide minerals are exposed to air and water and are oxidized to ferrous sulfate and sulfuric acid. Flowing water leaches away the ferrous sulfate and acid, forming acid mine water. In the water, the ferrous sulfate may be further oxidized to ferric sulfate which hydrolyzes to basic ferric sulfate or ferric hydroxide and additional sulfuric acid. These reactions are shown below:



The reaction yields two molecular weights of hydrogen ions (acidity) for each molecular weight of iron oxidized.



Depending upon pH, temperature, and concentration of constituents, the reaction proceeds:



and/or



Although these equations generally describe the reactions involved, the individual steps of the acid production processes and the influence of numerous variables such as oxygen concentration, inhibitors, reaction water composition, etc., on the reaction rate are not fully understood.

The variety of constituents found in mine drainage are produced by secondary reactions of sulfuric acid with compounds in adjacent rocks in the mine and along the stream valleys, and with various organic materials which may be encountered in the drainage environment. Such secondary reactions produce concentrations of aluminum, manganese, magnesium, calcium, sodium, and other constituents commonly found in the drainage water.

There is evidence to indicate that micro-organisms play a role in the formation of mine acid. There are conflicting opinions, however, among researchers as to the importance of the participation of micro-organisms in acid formation. Several bacterial species have been isolated from acid mine waters but the extent of their role in the acid reactions is still controversial among observers.

Since the supply of air and water is seldom lacking in the mine environment, the rate at which the acid is formed is a direct function of the amount of exposed sulfuric material. Consequently, the problem is aggravated with the opening of new mine tunnels and the abandonment of mined out areas in each operating mine. Caving and roof falls in abandoned mines increases the surface area exposed, thus increasing their acid forming potential.

Waste materials are often piled outside the mine and these, too, represent additional surface area exposed to the elements. This "gob" material is composed of impure coal, roof shale, and other high-sulfur rock. Because of the surface area involved and the sulfur content, the acid contribution from such piles may be particularly high. The use of this material for road surfaces used to be common practice, but is now discouraged in most states.

Many mine discharges are alkaline rather than acid and seldom create serious water pollution problems. Such alkaline discharges can be found throughout the bituminous coal fields but in the fields of western Pennsylvania, Ohio, and northern West Virginia, such discharges are the exception. In the southern Appalachian coal fields, alkaline mine discharges are common.

Mine drainage water has no part in the production of coal and is not used in the mining process. In fact, the removal of mine water is a sizable item in the total mining costs. Perhaps the major difference between mine drainage and a normal industrial waste is that mine drainage often continues at about the same rate of discharge after the termination of coal production. This fact points out a major portion of the mine drainage pollution problem. It has been variously estimated that at least 50 percent of the acid mine drainage in this region is from abandoned mines. (1) (6) (11).

CHEMICAL ANALYSIS OF MINE DRAINAGE

The character and degree of mineralization of mine drainage and the intensity of its effects on receiving water is evaluated by measurement of characteristic indicators or parameters. The parameters used in this study, methods of determination, and discussion of each, are described below:

1. pH

Method - Glass electrode pH meter

Reference - Standard Methods - 12th Ed., p. 225

Discussion - pH expresses the degree of acidity or alkalinity of a system and is defined as the logarithm of the reciprocal of the hydrogen ion concentration. Fractions of a pH scale do not represent arithmetic values but rather logarithmic values.

Natural waters usually exhibit a pH in the range of pH 6.0 to 9.0. Generally, acid mine drainage will vary from pH 2.0 to 6.0. The pH of the receiving stream varies according to the severity of pollution and the state of reaction of the pollutants.

2. Specific Conductance

Method - by conductivity bridge

Reference - Standard Methods (12th Edition, p. 280)

Discussion - Conductivity is expressed in terms of reciprocal resistance (mho) and is a measure of the electrical conducting power of the systems. The measurement is generally indicative of the concentration of dissolved constituents, particularly inorganic ones, and is thereby associated with the amount of dissolved solids in solution. Waters uncontaminated by mine drainage or other wastes exhibit conductivities generally less than 500 micromho. Measurement of mine drainage discharges varies generally from 500 to greater than 8,000 micromho. Receiving streams exhibit intermediate measurements depending upon the degree of dilution.

The approximate relation that 1 micromho = 0.65 milligrams per liter (mg/l) dissolved solids is satisfactory for estimating the dissolved solids content of many natural waters.

3. Total Acidity

Method - Potentiometric titration with sodium hydroxide to pH 8.3

Reference - Standard methods - 12th Edition, p. 439 (modified).

Discussion - The hot acidity test as modified consists of preliminary oxidation with 2 milliliters (ml) of 3 percent hydrogen peroxide solution, followed by heating to boiling, boiling for not less than 2 minutes, and titration while 90°C or higher to pH 8.3, using thermally-compensated pH meter or an uncompensated meter standardized at pH 8.3 with an appropriate buffer at 90°C - 95°C.

The method determines the acidity due to free mineral acids and acid salts. It does not measure the contribution to acidity of carbon dioxide.

Acidity is reported as milligrams per liter of CaCO_3 . This is not significantly different than reporting acidity as H_2SO_4 , since the molecular weight ratio $\text{CaCO}_3/\text{H}_2\text{SO}_4$ is 1.02.

Net Acidity - The acidity that is present in excess of alkalinity.

4. Alkalinity

Method - Potentiometric titration to pH 4.5

Reference - Standard Methods 12th Edition, p. 369

Discussion - This procedure measures the titratable alkalinity of the system which in most waters of Appalachia is essentially bicarbonate and/or carbonate in origin.

Under the conditions of the determination, a final positive alkalinity is measured when the acidity does not exceed the available alkalinity. It is therefore, essential that reactions yielding acidity be completed before the

alkalinity determination is attempted.
Alkalinity is reported as milligrams per liter of CaCO_3 .

5. Hardness (total)

Method - EDTA titration

Reference - Standard Methods - 12th Edition, p. 147

Discussion - This procedure measures the total concentration of such ions as calcium, magnesium, lithium, etc. It does not differentiate between species.

Unpolluted waters usually exhibit lower values in the order of 100 mg/l as CaCO_3 as compared to mine drainage where values may reach 500 to several thousand mg/l as CaCO_3 .

Hardness is reported as milligrams per liter of CaCO_3 .

6. Sulfate

Method - Turbidimetric analysis by precipitation as barium sulfate.

Reference - Standard Methods - 12th Edition, p. 291.

Discussion - A mole of sulfate accompanies each mole of sulfuric acid and sulfate is, therefore, an excellent indicator of the amount of mine drainage acidity formed. Unpolluted waters have concentrations of generally less than 20 mg/l; polluted waters frequently have concentrations of several hundred milligrams per liter.

7. Iron (total)

Method - Atomic absorption spectrophotometer.

Reference - See manuals of instrument manufacturers

Alternate method - Ferron-ortho-phenanthroline colorimetric.

Reference - Rainwater and Thatcher, 1960, p. 99.

Discussion - Generally mine drainage pollution contains iron in both ferrous and ferric states. Ferric iron does not contribute to acidity. Ferrous iron, a major contributor to acidity, is usually present in high concentrations in active mine drainage discharges. The presence of ferrous iron in a receiving stream usually indicates that the reactions have not gone to completion. The ferric iron present in systems above a pH of 3 is in the particulate state.

In receiving streams, measurements of the total iron concentration are complicated by sampling problems, since the amount of ferric iron present is dependent upon the stream velocity and sampling depth.

Unpolluted streams in Appalachia have iron concentrations less than 0.5 mg/l. Mine drainage influence may raise iron concentrations to several hundred mg/l.

8. Manganese

Method - Atomic absorption

Reference - See manuals of instrument manufacturers.

Alternative method - Persulfate oxidation.

Reference - Standard methods - 12th Edition, p. 489

Discussion - Concentrations of manganese in unpolluted streams do not usually exceed 0.05 mg/l. This indicator is usually associated with mine drainage pollution. Concentrations in the order of 5 mg/l to 20 mg/l are not uncommon in mine drainage.

9. Aluminum

Method - Atomic absorption

Reference - See manuals of instrument manufacturers.

Alternative method - Ferron orthophenanthroline colorimetric.

Reference - Rainwater and Thatcher, 1960, p. 99

Discussion - High concentrations of aluminum are usually found as a result of the leaching of deposits of clays associated with the coal bearing strata by the acid mine waters.

WATER QUALITY CRITERIA

Population growth combined with increased per capita use of water, expanding industrial requirements, and the mounting emphasis placed on recreational use of surface water all contribute to the importance of maximum protection and utilization of water resources. Certain constituents may affect a given water use at one concentration and affect another water use at a different concentration. Also certain characteristics or compounds may be in synergism with each other. For instance, the toxicity to fish of various elements or compounds varies substantially with pH.

The following criteria have been used to define the concentration or range of values at which concern over water quality for all uses is indicated, assuming that each characteristic is acting alone and not in synergism with another. The characteristics listed are those common to mine drainage waters and are of concern with most water uses:

<u>Characteristic</u>	<u>Area of Concern</u>
pH	Below 6.0, above 8.5
Specific Conductance	Higher than 350 micromhos/cm
Acidity (Hot to pH 8.3)	Exceeding the alkalinity
Alkalinity	(See Acidity and pH)
Total Iron	Higher than 0.5 mg/l
Manganese	Higher than 0.5 mg/l
Hardness	Higher than 150 mg/l
Calcium	Higher than 75 mg/l
Magnesium	Higher than 50 mg/l
Total Solids	Higher than 750 mg/l
Suspended Solids	Higher than 250 mg/l
Dissolved Solids	Higher than 500 mg/l
Color	Higher than 100 units
Turbidity	Higher than 200 units
Sulfates	Higher than 75 mg/l
Aluminum	Higher than 0.3 mg/l
Arsenic	Higher than 0.01 mg/l

ABATEMENT MEASURES

SOURCES OF MINE DRAINAGE POLLUTION

Several methods are presently used to recover bituminous coal, however all the methods fall within the two general types of either surface or underground operations.

Surface, or strip mining, is practical in areas where the rock and soil overburden is relatively thin. The thickness of overburden for economical removal depends not only on the coal reserves but also upon the type of machinery that can be utilized. In selected areas more than 100 feet of overburden rock have been stripped by means of large power shovels or other machinery. The first large strip trench that is formed is utilized for depositing the overburden from the adjacent trench. Consequently, in areas where the coal is relatively flat lying and the land surface is also of relatively low relief, strip mining disturbs large areas or blocks of land.

Where the coal crops out in a hill the overburden thickens quickly and surface mining is limited to stripping of the coal outcrop around the hill. In order to remove additional coal from inside the hill, auger mining is commonly used after the final strip out. These large augers, some of which are as much as seven feet in diameter, can mine several hundred additional feet into the hill.

In places where the overlying rock materials are thick, underground mining must be employed. Where the coal crops out at the land surface, a drift mine entry is constructed and mining is advanced into the coal bed. Where the coal bed is buried a considerable distance beneath the overlying rocks, a vertical shaft or a slope mine entry is constructed to the coal. Lateral entries are then driven into the coal bed.

All methods of surface and underground coal mining may result in some degree of mine drainage pollution. Acid drainage and silt from strip mining areas are serious problems in many local areas, but the underground mining operations contribute the bulk of the acid load to the streams.

Nearly all methods of mining and coal processing result in a problem of refuse disposal. The waste may be piled in the general vicinity of the mine and coal preparation plant or in other adjacent areas such as along roads, streams, or in abandoned areas inside the mines. Where the waste is high in sulfuric and other toxic materials, acid drainage will occur depending in large part upon the amount of water in contact with the material.

PROBLEMS

In most areas the rate and amount of acid formation is a direct function of the amount and surface area of the exposed sulfuric material associated with certain coal seams. The quantity of acid formed can be substantially lowered by reducing the contact between the sulfuric materials, air, and water. Apparently acid formation will continue as long as the sulfuric material remains in contact with air and water because some abandoned underground mines have drained significant amounts of acid for many decades.

Strip-mined lands left unreclaimed are often the source of sediment pollution of streams and can be a serious problem, especially in areas where the topography is steep and the spoil material is very difficult to stabilize. The abatement of water pollution from abandoned underground mining areas is hampered by inadequate technical information concerning remedial measures. Contour strip and auger mining that intercepts abandoned deep mining above the local drainage level presents extremely complicated mine drainage problems.

Disposal of the refuse materials from mines and coal preparation plants is one of the most difficult problems associated with active operations. Refuse piles are a major source of acid drainage, and washery residue spillage is a frequent source of the fine coal and silt pollution common in some streams. At most of the modern coal washery preparation plants, settling ponds and lagoons are utilized for disposal of washery residue wastes.

REMEDIAL PROCEDURES

Methods of reclamation are presently known which can reclaim most of the previously strip-mined lands and abate much of the associated water pollution. Although technical problems still exist, most of the difficult problems connected with abatement of strip-mine drainage pollution are economic and legal in nature.

Erosion and silt control can be obtained to an acceptable degree with proper drainage facilities, grading of the strip area, replanting vegetation, and construction of the necessary structures that will control the movement of water from the mined area to the stream channel.

Water quality control from the reclamation of strip-mined areas can be achieved to an acceptable degree in most areas if proper drainage is established, sulfuric and other toxic materials are covered, and pit and spoil areas are planted. Proper grading, covering of sulfuric material, and diversion and control of water away from contact with the coal beds and fine sulfuric materials at spoil areas have been demonstrated to be effective in reducing or eliminating stream pollution from these disturbed areas.

Impoundment of excess acid water with controlled release during periods of high stream flow is one method of disposal. This may be practical where types of coal mine wastes from active operations are disposed of in a similar manner.

Several methods of reducing the acid problem associated with deep mining have been tried. The major approaches to the problem have been mine sealing, chemical treatment, mine waste disposal, underground and surface drainage control, and acid disposal to streams with controlled flow.

Sealing of abandoned mines and other related remedial construction has been done in the past. Although a scientific evaluation of the long term results is not available, it is generally believed that some pollution abatement benefits are possible from these techniques.

Chemical treatment of the sulfuric and toxic materials in order to inhibit or reduce the formation of acid has been tried but the results were not promising. Chemical treatment or neutralization of acid water at active mines is a practical method of reducing acid loads to streams but at present this method is probably more costly than drainage control at the source for abandoned mine sites.

Control and prevention of surface water flowing into deep mines and drainage control and rapid removal of water from underground operations are known to be helpful in reducing the acid load.

In places where the abandoned mine area is below the local drainage level, flooding can be effective in reducing acid formation.

MINE DRAINAGE PROBLEMS IN THE MINOR BASINS

During the 1966 field season, a detailed stream pollution survey was conducted throughout the areas of mine drainage pollution in the upper Ohio River Basin. The survey was designed to gather stream water quality data in the principal problem areas where existing quality information was meager. Six samplings at each of some 165 stream locations, and corresponding streamflow determinations, were accomplished in the drainage area described in this report.

Following is a description of the mine drainage problem in each of the major tributary drainage units comprising the upper Ohio River Basin. Data from the 1966 special stream survey, previous stream surveys conducted by the Ohio River Basin Project, and other pertinent data have been utilized in the following minor basin discussions.

ALLEGHENY RIVER

Description

The Allegheny River rises near Coudersport in northwestern Pennsylvania. It flows westward and then northward into New York then turns south near Salamanca, New York, and flows southwestward through Pennsylvania. It joins the Monongahela River at Pittsburgh to form the Ohio River. The total length of the Allegheny River is about 325 miles (Figure 3).

The basin embraces 11,730 square miles in western New York and western Pennsylvania. It is about 175 miles long on a north-south axis and its maximum width is about 130 miles. Some 1,965 square miles of New York and 9,765 square miles of Pennsylvania are in the watershed. Adjacent are the Great Lakes-St. Lawrence River basin on the north, the Susquehanna River basin on the east, the Monongahela River basin on the south, and the Beaver River basin or direct drainage to the Ohio River on the West. Principal tributaries to the Allegheny are the Kiskiminetas and Clarion Rivers, and Mahoning, Redbank, French, Oil, Tionesta, and Conewango Creeks.

The Allegheny River basin is in the southern New York and Kanawha sections of the Appalachian Plateau physiographic province. The southern New York section represents a mature glaciated plateau of moderate relief. The Kanawha section represents a mature unglaciated plateau of fine texture with moderate to strong relief.

About 25 percent of the topography of the basin has been modified by the advance of the last continental ice sheets. The line

of farthest advance crosses the northwestern part of the region running from just west of Franklin, Pennsylvania, to just east of Jamestown, New York. The topography of the glaciated area is generally that of rolling plains with gentle slopes and many lakes and swamps have been formed on the glacial deposits. Below and to the east of the glacial advance, the topography displays moderate to strong relief. In the mountain upland and high plateau areas of the basin, the land is highly dissected by its drainage. For example, the Conemaugh River and Loyalhanna Creek gorges are over 1,000 feet deep. The highest points in the upland areas are above 2,500 feet in elevation.

The major cities in the Allegheny basin are heavily industrialized in the following major industry groupings: Primary metal products; electrical machinery, equipment, and supplies; fabricated metal products; and stone, clay, and glass products. Oil production, coal mining, and agriculture are additional major economic activities in the basin. The principal cities in the basin and their 1960 populations are Johnstown, Pennsylvania - 53,949; Jamestown, New York - 41,818; Wilkesburg, Pennsylvania - 30,066; New Kensington, Pennsylvania - 23,485; and Olean, New York - 21,868.

All of the Allegheny River basin is contained in the Appalachian Region as defined by the Appalachian Regional Development Act of 1965.

Coal Reserves and Mining Activity

Bituminous coal reserves are present in 14 of the 19 Pennsylvania counties that are wholly or partly in the basin, amounting to some 57 percent of the total basin land area. Coal has been mined in all but one of these 14 counties. The recoverable coal reserve in the Allegheny River basin portion of these counties is estimated to be nearly 11 billion tons. There are no coal deposits in the New York portion of the basin.

By 1877, bituminous coal mining in Western Pennsylvania had evolved into a significant industry, producing 1.3 million tons in that year. From this early beginning, production of coal in western Pennsylvania has not fallen under 50 million tons per year since 1894. A peak annual production of 177 million tons was reached in 1918. Production in the Allegheny River basin in 1965 was 30 million tons (14). The principal coal producing counties were Armstrong, Clarion, and Indiana.

Streams Affected and Present Quality

The long history of coal mining has left the Allegheny basin with a legacy of stream pollution from coal mine drainages. Significant mine drainage stream pollution exists in 14 Pennsylvania counties of the basin (Figure 3 and Table 6). Nearly all of the affected streams are found in that portion of the watershed south of a general east-west line between Franklin, Pennsylvania, in Venango County and St. Marys, Pennsylvania in Elk County. Stream pollution conditions from mine drainage are particularly acute in terms of numbers of streams and total length of streams affected in Armstrong, Cambria, Clarion, Indiana, Somerset, and Westmoreland Counties (Figure 3). Table 5 presents the miles of streams, by watershed, considered by this survey to be polluted by mine drainage in the Allegheny River basin.

Although the Allegheny River receives small amounts of mine drainage from minor tributaries in Venango County, the first mine drainage of any dimension is received from the Clarion River in western Clarion County. The Clarion River (Sta. 524) discharged an average net acid load of 63 tons per day to the Allegheny River during the 1966 survey.

The Clarion River is polluted by mine drainage in its lower section. At the Cooksburg station, (Sta. 523) the Clarion exhibited a pH range of 5.7 to 6.7. At its mouth (Sta. 524), the Clarion carried a net acid load of 63 tons per day and exhibited a pH range of 4.1 to 5.3 during the survey. Between Cooksburg and the mouth, the Clarion River receives mine drainage from several very poor quality tributaries. The principal contributing tributaries and their acid loads are presented in the following table.

Table 3

Lower Clarion River tributaries, acid loadings

Sampling Station Number	Stream	Location	pH Range	Average Net Acid Load Tons/day
517	Mill Creek	Mouth	2.9-3.2	8.5
516	Toby Creek	Mouth	2.8-3.1	24
515	Piney Creek	Mouth	3.4-4.0	9.6
514	Deer Creek	Mouth	3.2-3.4	6.9
513	Licking Creek	Mouth	2.6-3.1	8.4

In the moderately polluted upper Clarion River basin, mine drainage enters the headwaters of East Branch Clarion River. At Station 522 below the East Branch Reservoir, the pH during the sampling period ranged from 5.5 to 6.6 (Figure 3, table 6) and the net acidity was relatively small, 4 tons per day. The main-stem Clarion receives only minor drainage increments below Station 522 until the entry of Toby Creek in southern Elk County. During the sampling period, Toby Creek added a net acid load of 7.5 tons per day to the Clarion and exhibited a pH range of 3.6 to 4.1 (Sta. 518).

Very little mine drainage enters the Clarion River between Toby Creek and Station 523 on the river below Cooksburg, Pennsylvania. At this point the pH ranged from 5.7 to 6.7 and the average alkalinity slightly exceeded the average acidity. Total mineralization of the water was relatively low.

The Clarion River watershed contains more than 200 miles of mine drainage polluted streams. The principal problem areas are acid tributary watersheds in the lower basin in Clarion County. The net acid load received by the Clarion River in this reach is about 57 tons per day.

At Station 565, Allegheny River at Parker Bridge, the Allegheny assimilated the large acid load from the Clarion with negligible water quality effects. The minimum pH at this location was 6.4, and the alkalinity was consistently greater than the acidity. Between the Clarion and Kiskiminetas Rivers the Allegheny receives acid loads from Redbank (Sta. 525) and Crooked Creeks (Sta. 560). These streams discharge net acid loads of 0.2 ton and 17 tons per day, respectively.

Thirty miles upstream from Pittsburgh, the Kiskiminetas River enters the Allegheny. During the survey it discharged a massive average net acid load of 494 tons per day as measured at Vandergrift, Pennsylvania (sta. 567). The pH of the stream ranged from 3.0 to 3.6 and the alkalinity was depleted throughout the survey. The Kiskiminetas River is considered to be the most acid polluted large stream in the Ohio River basin. Long-term water quality records show that the stream discharges an average of 329 tons per day of acidity to the Allegheny River (15).

Within the Kiskiminetas watershed there are about 485 miles of streams polluted by mine drainage. Many streams are acid even in the upper headwater areas of Somerset and Cambria Counties. The Conemaugh River above Johnstown (Sta. 581) carried a net acid load of 25 tons per day originating from the watersheds of both the North and South Branches.

Stony Creek, which enters the Conemaugh River at Johnstown, drains 466 square miles of the southern portion of the headwaters area and contains more than 100 miles of acid streams. The principal tributaries of Stony Creek are polluted by mine drainage. Shade Creek carried a net acid load of 13 tons per day (Sta. 494). Additional acid loads to the Conemaugh River between Johnstown and at Seward, Pennsylvania, raised the average net acid load in the river to 86 tons per day (Sta. 579).

Blacklick Creek and many of its tributaries are acid over their entire length. The Blacklick watershed contains over 100 miles of mine drainage polluted streams. The pH at the mouth of Blacklick Creek ranged from 2.5 to 2.9 and the total acidity concentration from 452 to 897 mg/l (Sta. 573). The net acid load of 208 tons/day discharged from Blacklick Creek is 42 percent of the net acid load discharged by the Kiskiminetas River.

A net acid load of 88 tons per day was measured on the North Branch Blacklick Creek at Nipton in Cambria County (Sta. 577). Although the watershed above this point represents only 14 percent of the Blacklick Creek watershed, 41 percent of the total net acid load of Blacklick Creek was measured here. The load at this station amounts to 18 percent of that measured in the Kiskiminetas at Vandergrift. Two Lick Creek discharged a net acid load of 38 tons per day to Blacklick Creek (Sta. 574).

The Conemaugh River below Blairsville (Sta. 575) carried a net acid load of 397 tons per day, contained no alkalinity, and exhibited a pH range of 2.9 to 3.3. Continuing downstream, the Kiskiminetas River is formed where the Conemaugh River and Loyalhanna Creek converge just above the Armstrong-Indiana County line. Loyalhanna Creek is an acid stream over much of its length and contributed a net acid load of 57 tons per day. The pH ranged from 3.3 to 4.7 and the alkalinity was completely depleted (Sta. 570).

From the origin of the Kiskiminetas River to its mouth there are several small acid contributing tributaries. The largest of these is Blacklegs Creek which contained a net acid load at its mouth of five tons per day (Sta. 569).

During the 1966 water quality survey, the Kiskiminetas River at Vandergrift (Sta. 567) contained an average manganese concentration of 23.2 mg/l. High average manganese concentrations were found at station 579 (29.8 mg/l) and station 567 (23.2 mg/l) in the Conemaugh and Kiskiminetas Rivers below Johnstown. Manganese concentrations in tributaries to the Conemaugh-Kiskiminetas main-stem averaged about one-tenth of the main-stem concentrations. The higher manganese levels in the main-stem below Johnstown are probably due to discharges from the steel industry.

The Conemaugh-Kiskiminetas River is an acid stream over its entire length and the river system is grossly polluted by coal mine drainage. Acid, sterile streams in this watershed are the rule and not the exception.

Although the Allegheny River possessed adequate dilution and neutralizing capability to assimilate mine drainage water received above the mouth of the Kiskiminetas River, the water quality is significantly degraded below this point. The Allegheny River at Natrona, Pennsylvania (Sta. 566) carried an average net acid load of 245 tons per day and had a pH range of 4.0 to 6.8. The total acidity concentration exceeded the alkalinity concentration during two thirds of the survey period. However, the acidity concentration was generally below 30 mg/l.

A one-year study during 1965-66 conducted by the University of Pittsburgh for the Ohio River Basin Project, Federal Water Pollution Control Administration, measured an average net acid load of 384 tons per day discharged from the Kiskiminetas River and a net alkalinity load of 401 tons per day from the Allegheny River at Pittsburgh (16).

Water quality records show that acid conditions in the lower Allegheny River are particularly acute during periods of low flow when the percentage contribution of flow to the main-stem by the Kiskiminetas is greater than normal. When roughly 30 percent of the flow in the Allegheny is from the Kiskiminetas River, fish kills are expected. One million fish were killed in the Allegheny River below the Kiskiminetas due to acid conditions during the period August 19-23, 1966.

Among the major tributaries of the upper Ohio River Basin, the Allegheny is second only to the Monongahela in the severity and intensity of stream pollution by coal mine drainage. It contains the most acid large stream in the Ohio River Basin and over 1000 miles of polluted streams. Those streams in the Allegheny basin that carried an average net acid load of more than five tons per day are listed in Table 4. Miles of streams affected by mine drainage in the Allegheny River basin are listed in Table 5.

Table 4

Allegheny River basin streams
carrying more than five tons
per day net acidity

Sampling Station Number	Stream	Average Net Acid Load, tons/day
519	Little Toby Creek, tributary to Toby Creek, Elk County	8.4
518	Toby Creek at the Clarion River (Elk County)	7.5
517	Mill Creek at the Clarion River	8.5
516	Toby Creek at the Clarion River (Clarion County)	24
515	Piney Creek at the Clarion River	9.6
514	Dear Creek at the Clarion River	6.9
513	Licking Creek at the Clarion River	8.4
524	Clarion River at Mouth	63
558	Pine Run at Mahoning Creek	6.1
560	Crooked Creek at Mouth	17
493	Dark Shade Creek at the Kiskiminetas River	12
574	Two Lick Creek near Grayson, Pa.	38
577	North Branch Blacklick Creek at mouth	88
573	Blacklick Creek at the Kiskiminetas River	213
494	Shade Creek at Hillsboro, Pa.	13
570	Loyalhanna Creek at the Kiskiminetas River	57
569	Blacklegs Creek at Mouth	5.0
579	Conemaugh River at U.S.G.S. Gage at Seward	86
567	Kiskiminetas River at Vandergrift, Pennsylvania	494
566	Allegheny River at Natrona, Pennsylvania	245

Table 5

Lengths of streams polluted by mine drainage,
Allegheny River basin

	Drainage Area (sq.mi.)	Continuously Polluted (miles)	Intermittently Polluted (miles)	Total
Allegheny River	11,733	30		30
Minor Tributaries		281	58	339
Kiskiminetas River	1,892	24		24
Tributaries		10	5	45
Conemaugh River	1,376	48		48
Tributaries		310	6	316
Loyalhanna Creek	300	21		21
Tributaries		31		31
Clarion River	1,232	21		21
Tributaries		<u>173</u>	<u>18</u>	<u>191</u>
979 miles + 87 mi. = 1066 miles.				

Table 6 - Water quality data, Allegheny River basin

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
490	7	Min. 6.5 Max. 7.1 Avg. 6.8	0.0 12.0 6.7	13.0 32.0 19.6	76.0 172.0 136.1	34.0 145.0 106.0	0.0 2.0 0.6	0.1 0.7 0.4	0.0 2.5 1.1(6)*	8.4 70.0 19.9
492	7	Min. 6.2 Max. 7.8 Avg. 6.9	3.0 10.0 6.7	5.0 15.0 9.9	7.0 60.0 34.0	4.0 25.0 12.9	0.0 1.0 0.2	0.0 0.2 0.1	0.0 2.1 0.5(6)	1.5 83.0 17.7
493	7	Min. 2.8 Max. 4.4 Avg. 3.3	107.0 445.0 270.3	0.0 0.0 0.0	148.0 363.0 260.3	48.0 825.0 501.4	7.5 73.2 46.7	0.2 8.2 5.1	10.4 30.8 22.3(6)	9.6 50.0 20.5
494	7	Min. 2.7 Max. 3.8 Avg. 3.1	53.0 255.0 148.0	0.0 0.0 0.0	86.0 332.0 184.9	120.0 490.0 310.7	6.7 22.1 12.0	0.1 6.0 3.4	2.5 30.8 15.8(6)	9.0 120.0 49.6
495	7	Min. 6.5 Max. 7.4 Avg. 7.1	0.0 25.0 9.0	13.0 33.0 22.9	94.0 502.0 297.9	71.0 475.0 284.4	0.4 2.2 1.3	0.0 0.4 0.2	0.3 3.6 2.1(6)	5.0 65.0 18.9
499	7	Min. 6.3 Max. 7.2 Avg. 6.8	2.0 12.0 7.1	13.0 43.0 27.3	60.0 285.0 143.0	80.0 135.0 106.8(6)	0.0 1.0 0.3	0.0 0.2 0.1	0.0 2.9 1.2(6)	5.4 116.0 26.2
501	7	Min. 3.2 Max. 6.0 Avg. 4.3	9.0 105.0 36.9	0.0 12.0 3.0	60.0 127.0 85.6	36.0 194.0 108.3	3.1 12.2 6.4	0.0 0.8 0.3	1.1 8.4 3.3(6)	10.5 40.0 22.7
503	6	Min. 7.0 Max. 7.9 Avg. 7.2	0.0 14.0 7.0	39.0 73.0 55.5	68.0 152.0 110.7	15.0 25.0 19.2	0.1 1.0 0.5	0.2 0.3 0.3	0.7 3.9 1.6	170.0 600.0 380.0
504	6	Min. 6.7 Max. 6.9 Avg. 6.8	0.0 19.0 12.5	35.0 62.0 46.7	337.0 838.0 562.7	5.0 30.0 16.5	0.0 4.8 1.5	0.0 0.5 0.2	0.7 30.2 9.7	7.0 23.8 15.2

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
506	6	7.1 7.4 7.3	0.0 18.0 7.5	46.0 81.0 65.2	75.0 135.0 99.5	5.0 30.0 19.0	0.3 1.4 0.8	0.2 0.5 0.3	0.1 6.7 2.4	470.0 1900.0 969.2
508	6	6.8 7.8 7.4	0.0 13.0 7.0	15.0 40.0 26.8	25.0 59.0 36.7	9.0 35.0 22.3	0.1 0.3 0.2	0.0 0.2 0.1	0.0 2.0 0.8	6.0 38.0 18.4
509	6	7.6 8.7 8.0	0.0 9.0 4.7	46.0 74.0 60.7	68.0 132.0 90.3	15.0 70.0 33.5	0.4 1.0 0.7	0.0 0.5 0.2	1.0 2.8 1.9	740.0 3280.0 1752.7
510	6	7.1 7.7 7.4	0.0 12.0 5.5	24.0 52.0 35.3	59.0 84.0 68.7	20.0 55.0 45.3	0.0 0.5 0.3	0.0 0.3 0.1	0.0 2.1 1.1	8.0 28.0 20.0
511	6	4.8 7.5 6.2	10.0 49.0 24.8	3.0 16.0 7.3	256.0 290.0 278.0	150.0 260.0 219.2	0.3 4.3 2.0	3.6 5.8 4.7	1.5 10.5 4.4	10.8 16.0 13.6
512	6	4.4 6.4 5.0	18.0 39.0 25.5	0.0 10.0 3.7	81.0 120.0 100.8	50.0 110.0 90.8	0.5 0.8 0.6	1.9 2.9 2.3	1.4 4.6 2.9	19.6 186.0 53.3
514	6	3.2 3.4 3.3	101.0 157.0 134.0	0.0 0.0 0.0	134.0 245.0 188.7	140.0 390.0 280.8	1.1 14.8 4.8(5)	7.2 11.4 8.9(5)	4.9 16.7 11.6(5)	14.5 24.0 19.3

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
515	Min.	3.4	72.0	0.0	268.0	105.0	0.7	11.0	2.8	1.0
	Max.	4.0	218.0	0.0	340.0	450.0	4.8	17.8	25.5	90.0
	Avg.	3.7	140.0	0.0	288.8	342.5	3.1	14.0	12.2	24.3
516	Min.	2.8	735.0	0.0	276.0	350.0	79.2	12.0	67.2	3.0
	Max.	3.1	1226.0	0.0	552.0	1900.0	144.0	60.0	139.4	15.0
	Avg.	2.9	969.7	0.0	444.7	964.2	110.4(3)	38.0	108.5(4)	10.0
517	Min.	2.9	187.0	0.0	69.0	165.0	1.4	20.2	4.0	5.1
	Max.	3.2	465.0	0.0	460.0	775.0	18.0	29.3	27.4	17.5
	Avg.	3.1	279.7	0.0	337.0	385.0	10.6	26.0	15.0	11.8
518	Min.	3.6	62.0	0.0	221.0	140.0	0.2	5.4	6.1	9.5
	Max.	4.1	236.0	0.0	313.0	440.0	1.2	13.8	12.6	54.9
	Avg.	3.9	125.7	0.0	271.8	285.8	0.8	7.8	9.8	28.8
519	Min.	3.0	132.0	0.0	300.0	150.0	0.4	9.6	2.0	8.2
	Max.	3.4	2840.0	0.0	4160.0	950.0	60.1	38.0	36.0	20.3
	Avg.	3.2	651.8	0.0	1032.8	431.7	13.3	15.8	18.0	14.6
522	Min.	5.5	10.0	2.0	20.0	23.0	0.1	0.5	0.2	121.0
	Max.	6.6	18.0	7.0	36.0	365.0	0.2	0.9	1.5	170.0
	Avg.	6.0	13.5	3.3	24.3	96.2	0.2	0.8	1.0	147.8
523	Min.	5.7	1.0	10.0	50.0	15.0	0.1	0.2	0.8	232.0
	Max.	6.7	22.0	18.0	98.0	75.0	2.6	0.5	6.6	335.0
	Avg.	6.5	13.3	13.5	86.0	55.8	1.1	0.3	3.7	286.3
524	Min.	4.1	25.0	0.0	100.0	90.0	0.2	2.3	1.9	68.0
	Max.	5.3	40.0	4.0	158.0	210.0	1.4	4.4	7.5	2000.0
	Avg.	4.7	32.7	2.0	113.8	117.2	0.7	3.0	4.5	761.3

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
525	6	6.4 7.2 6.8	9.0 19.0 13.0	6.0 17.0 11.8	155.0 240.0 183.8	45.0 215.0 159.2	0.2 1.2 0.5	0.0 1.0 0.5	0.9 5.8 2.2	44.0 128.0 85.3
554	6	6.4 7.4 6.9	0.0 18.0 6.8	35.0 70.0 51.8	20.0 62.0 35.7	6.0 35.0 17.7	0.5 1.4 0.8	0.0 0.2 0.1	0.4 5.0 1.5	6.5 17.7 11.9
555	6	6.3 7.4 6.7	0.0 18.0 10.0	8.0 40.0 21.8	90.0 149.0 127.7	110.0 145.0 130.8	0.3 0.4 0.4	0.0 0.3 0.1	1.0 1.9 1.3	12.0 38.0 24.3
557	6	6.6 7.0 6.8	1.0 15.0 9.5	11.0 36.0 21.2	120.0 215.0 158.2	120.0 195.0 157.0(5)	0.0 0.7 0.3	0.1 0.7 0.3	0.2 3.2 1.1	95.0 300.0 193.7
558	6	2.8 3.4 3.1	97.0 336.0 206.0	0.0 0.0 0.0	207.0 314.0 256.5	340.0 560.0 411.3(4)*13.8(5)	2.6 34.6 6.4(5)	4.1 10.2 6.4(5)	3.2 39.8 16.9(5)	8.0 14.2 11.6
560	6	3.7 4.7 4.2	33.0 120.0 74.2	0.0 0.0 0.0	111.0 222.0 169.5	190.0 450.0 287.0(5)	0.0 0.6 0.4	1.0 4.8 2.8	1.6 12.3 5.8	50.0 104.0 76.2
561	6	6.9 7.1 7.0	0.0 90.0 21.3	31.0 280.0 78.0	147.0 1480.0 411.7	112.0 1100.0 329.4(5)	0.0 1.3 0.6	0.0 0.3 0.2	0.0 3.8 1.4	8.8 14.0 11.6
562	6	6.4 7.0 6.8	0.0 20.0 10.2	13.0 30.0 20.2	147.0 345.0 206.3	160.0 400.0 233.8(4)	0.0 1.6 1.0	0.7 1.1 0.9	0.0 2.2 1.0	12.8 32.0 23.5

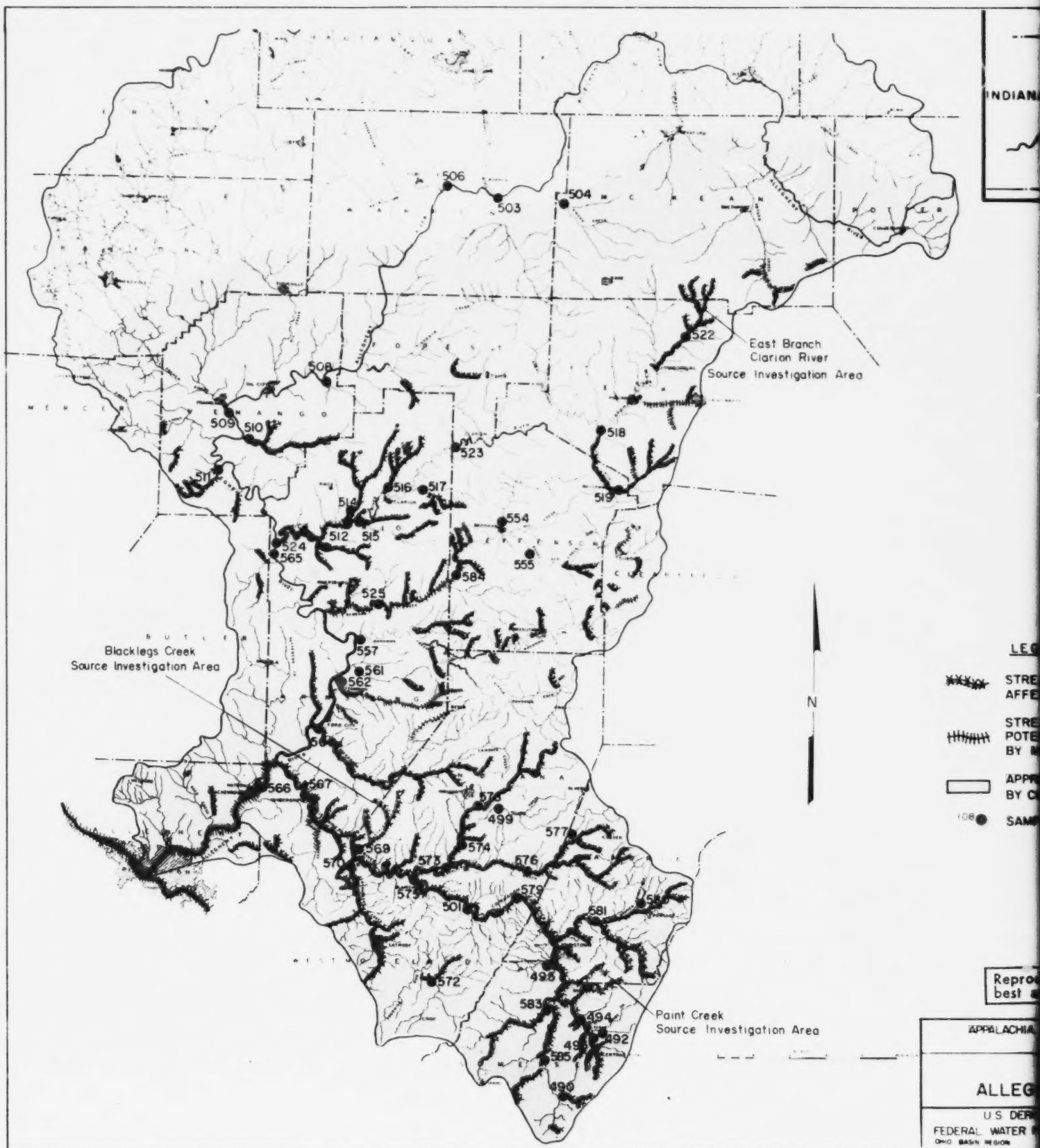
Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
565	Min. Max. Avg.	6.4 7.7 7.0	0.0 13.0 7.7	36.0 54.0 45.8	74.0 140.0 102.0	28.0 175.0 62.3	0.3 0.7 0.5	0.2 0.7 0.5	0.7 3.1 1.8	1392.0 4876.0 2994.3
566	Min. Max. Avg.	4.0 6.8 5.7	2.0 158.0 37.3	0.0 23.0 9.8	115.0 240.0 167.5	95.0 270.0 178.8(4)	0.2 1.1 0.5(5)	1.6 5.2 3.1	0.5 5.1 2.4(5)	1866.0 12840.0 7574.8
567	Min. Max. Avg.	3.0 3.6 3.2	159.0 259.0 221.7	0.0 0.0 0.0	264.0 454.0 343.3	425.0 700.0 552.5(4)	5.5 32.6 12.2	9.0 76.9 23.2	12.2 39.8 21.0	421.0 1136.0 853.2
569	Min. Max. Avg.	3.1 5.0 4.3	60.0 171.0 112.8	0.0 2.0 0.5	80.0 382.0 274.2	340.0 600.0 518.0(5)	3.4 21.6 10.7	1.9 2.6 2.3	5.6 31.9 14.3	5.0 29.0 15.3
570	Min. Max. Avg.	3.3 4.7 3.7	104.0 193.0 141.8	0.0 0.0 0.0	125.0 500.0 348.2	120.0 680.0 435.0(5)	2.4 18.5 11.4	4.1 8.2 5.8	0.0 17.9 6.2	60.0 296.0 136.3
572	Min. Max. Avg.	6.7 10.1 8.0	5.0 11.0 8.7	12.0 39.0 22.2	21.0 52.0 35.2(5)	0.0 15.0 6.5(4)	0.0 1.6 0.3	0.0 0.2 0.1	0.0 4.4 1.7	16.5 37.9 25.2
573	Min. Max. Avg.	2.5 2.9 2.7	42.0 897.0 601.5	0.0 0.0 0.0	239.0 269.0 248.8	130.0 920.0 522.5(4)	48.0 158.4 93.8	3.2 5.5 4.0	22.2 168.0 82.8	53.0 330.0 125.2
574	Min. Max. Avg.	3.0 4.3 3.3	189.0 467.0 308.7	0.0 0.0 0.0	222.0 381.0 284.0	130.0 750.0 528.0(5)	27.8 40.8 34.7	1.2 5.7 3.8	10.8 84.0 44.5	21.0 86.0 50.3

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
575	Min. 6 Max. 6 Avg. 6	2.9 3.3 3.2	167.0 274.0 207.3	0.0 0.0 0.0	234.0 320.0 274.5	440.0 475.0 456.3(4)*	4.3 12.5 7.8	8.8 22.8 15.1	6.4 26.3 13.9	450.0 901.0 724.8
576	Min. 6 Max. 6 Avg. 6	2.7 2.8 2.8	614.0 1592.0 999.8	0.0 0.0 0.0	247.0 410.0 311.2	1450.0 2500.0 1845.8	91.0 312.0 215.2	3.5 6.5 4.6	70.0 176.4 124.8(5)	56.0 105.0 73.8
577	Min. 6 Max. 6 Avg. 6	2.7 2.9 2.8	711.0 1572.0 1010.5	0.0 0.0 0.0	110.0 342.0 272.0(5)	1150.0 2500.0 1720.0(5)	163.2 374.4 257.1	2.9 7.0 5.2	14.0 179.2 96.8	21.0 47.5 35.4
578	Min. 6 Max. 6 Avg. 6	3.0 5.2 3.9	95.0 261.0 169.5	0.0 2.0 0.7	202.0 414.0 283.0	50.0 450.0 315.0(5)	1.4 11.0 5.5(5)	2.6 5.9 4.0	7.8 35.3 19.1(5)	8.0 42.0 28.1
579	Min. 6 Max. 6 Avg. 6	5.4 6.8 6.2	79.0 160.0 106.5	3.0 76.0 19.3	140.0 370.0 257.8	400.0 840.0 580.0(5)	7.7 67.2 22.0	22.0 41.7 29.8(5)	0.1 47.6 12.9	229.0 512.0 373.3
580	Min. 6 Max. 6 Avg. 6	6.7 8.3 7.2	0.0 15.0 4.0	20.0 102.0 71.5	80.0 130.0 95.2	20.0 88.0 49.6(5)	0.0 1.5 0.5	0.2 0.6 0.3	0.0 2.5 0.6	0.5 3.8 2.4
581	Min. 6 Max. 6 Avg. 6	3.0 4.2 3.4	184.0 330.0 244.2	0.0 0.0 0.0	212.0 452.0 336.3	475.0 805.0 598.0(5)	10.6 26.4 17.8	3.7 5.7 4.4	0.0 41.4 17.7	0.0 80.0 40.9
583	Min. 6 Max. 6 Avg. 6	5.1 6.9 6.4	0.0 43.0 17.0	2.0 38.0 20.3	95.0 200.0 115.8	62.0 215.0 147.4(5)	0.0 0.5 0.2	0.0 2.3 1.1	0.2 3.6 1.5	0.1 12.0 3.9
584	Min. 6 Max. 6 Avg. 6	6.0 7.2 6.8	0.0 16.0 6.7	10.0 35.0 26.0	113.0 140.0 128.7	75.0 120.0 97.5	0.6 3.6 1.7	0.5 1.4 0.9	0.9 6.4 2.4	28.0 82.5 59.9

Map Station	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
585	6	6.6	5.0	12.0	187.0	155.0	0.0	0.2	0.0	14.5
	Min.	6.6	5.0	12.0	187.0	155.0	0.0	0.2	0.0	14.5
	Max.	7.0	16.0	28.0	237.0	235.0	0.5	0.7	1.9	30.0
	Avg.	6.8	11.5	19.7	210.0	193.8(5)	0.2	0.5	0.6	23.8

* () Indicates the number of samples used in averages when other than the maximum.

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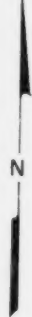
3



VICINITY MAP

LEGEND

- STREAMS CONTINUOUSLY AFFECTED BY MINE DRAINAGE
- STREAMS INTERMITTENTLY OR POTENTIALLY AFFECTED BY MINE DRAINAGE
- APPROXIMATE AREA UNDERLAIN BY COAL-BEARING DEPOSITS
- 108 SAMPLING STATION



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APPALACHIA MINE DRAINAGE POLLUTION REPORT
ALLEGHENY RIVER BASIN <i>46 a</i>
U.S. DEPARTMENT OF THE INTERIOR FEDERAL WATER POLLUTION CONTROL ADMINISTRATION OHIO BASIN REGION

FIGURE 3

MONONGAHELA RIVER

Description

The Monongahela River basin includes about 7,380 square miles in northern West Virginia, southwestern Pennsylvania, and northwestern Maryland. West Virginia contains the largest share of the basin, 4,150 square miles. Pennsylvania and Maryland contain approximately 2,730 and 500 square miles, respectively. The basin is bounded on the west by main stem Ohio River drainage, on the south by the Little Kanawha and Kanawha River basins, on the east by the Potomac River basin, and on the north by the Allegheny River basin. It includes all or part of 11 counties in West Virginia, six counties in Pennsylvania, and one county in Maryland.

The Monongahela River is formed by the confluence of the West Fork and Tygart Valley Rivers at Fairmont, W. Va. The river flows 129 miles in a northerly direction and joins the Allegheny at Pittsburgh to form the Ohio River. Major tributaries are the Youghiogheny, Cheat, West Fork, and Tygart Valley Rivers. The Monongahela basin is maintained for navigation by lock and dam installations through its entire length.

The Monongahela River basin is located in the Appalachian Plateaus physiographic province, mostly in the Kanawha section and partly in the Allegheny Mountains section. This area represents a mature plateau of fine texture with moderate to strong relief. Erosion has reduced almost all the land area to slope, the terrain is rugged and the valleys are deep and narrow. Flat areas are limited to narrow flood plains and some terraces and flat-topped hills. The elevations of the basin range from a high of about 4,600 feet in the headwaters of the Cheat River to about 700 feet at Pittsburgh, Pa., giving a maximum relief of nearly 4,000 feet.

Most of the agriculture, manufacturing, mining, and urban and industrial centers are located in the western half of the watershed. Much coal mining has occurred in the basin, and it continues to be a major industry. Industries are concentrated along the West Fork River and main stem Monongahela River. The principal communities in the basin and their 1960 populations are McKeesport, Pa. - 45,489; Clarksburg, W. Va. - 28,112; Morgantown, W. Va. - 27,487; Fairmont, W. Va. - 27,477; and West Mifflin, Pa. - 27,289.

All of the Monongahela River basin is contained in the Appalachian Region.

Coal Reserves and Mining Activity

Bituminous coal reserves are present in 17 of the 18 counties that are wholly or partly in the basin. These reserves have been estimated to be about 23 billion tons. Coal has been mined in this area for some 200 years. Some mining has been done in all 17 counties, and in 1965 production from approximately 750 mines was about 65 million tons (14) (17) (18). Marion, Monongalia, Harrison, Preston, and Barbour in West Virginia, and Green, Washington, Westmoreland, Fayette, Somerset, and Allegheny in Pennsylvania were the principal producing counties.

Streams Affected and Present Quality

Mine drainage pollution of streams is the major water quality problem in the basin. It is present in all 17 counties where coal has been mined (Figure 4 and Table 9).

Among the major tributaries of the upper Ohio River Basin, the Monongahela River basin is the most intensely polluted by coal mine drainage. The basin contains more than 1,600 miles of polluted streams. In general, the western half of the basin has the most serious stream pollution conditions. Mine drainage problems are particularly acute in terms of numbers and total length of streams affected in Westmoreland, Fayette, and Green Counties, Pennsylvania and in Monongalia, Marion, Harrison, Taylor, Barbour, and Preston Counties, W. Va. Table 7 shows the miles of streams, by watershed, considered by this survey to be polluted.

A comprehensive water quality survey of the streams in the Monongahela River Basin was conducted during 1965-66. Those streams that carried more than five tons per day of net acidity during the survey are shown in Table 8.

Although the West Fork River receives small amounts of mine drainage from minor headwater tributaries in Lewis County, W. Va., the first mine drainage of serious proportions is received in Harrison County from virtually every tributary including Isaacs Creek, Browns Creek, and Elk Creek. Elk Creek alone discharges an average of 5.8 tons per day net acidity, (Sta. 132). At a sampling station just below Clarksburg, W. Va., (Sta. 122) the West Fork River discharged an average net acidity load of 6.5 tons per day and had an average pH of 5.5. The West Fork becomes grossly polluted by mine drainage in its lower section between Clarksburg and Fairmont, W. Va. Many poor quality tributaries enter the stream in this reach. Simpson Creek near Bridgeport, W. Va., (Sta. 120) contributed an average daily net

Table 7

Lengths of streams polluted by mine drainage,
Monongahela River basin

	Drainage Area	Continuous Miles	Intermittent Miles	TOTAL
Monongahela River	8,038	129		129
Minor Tributaries		341	33	374
Youghiogheny River	1,768		105	105
Tributaries		129	27	156
Cheat River	1,424	19	17	36
Tributaries		134	9	143
West Fork River	882	30	18	48
Tributaries		371	20	391
Tygart Valley River	1,369	48		48
Tributaries		181	60	241
		1,382	+ 289	= 1,671
		GRAND TOTAL:		1,671

Table 8 - Monongahela River basin streams
carrying more than five tons
per day net acidity

<u>Station No.</u>	<u>Stream</u>	<u>Location</u>	<u>Average Net Acid Load Tons/Day</u>
117	West Fork River	Above Fairmont, W.Va.	156
120	Simpson Creek	Below Bridgeport, W. Va.	29
122	West Fork River	Below Clarksburg, W.Va.	6.5
132	Elk Creek	Near Clarksburg, W.Va.	5.8
104	Tygart Valley River	Colfax, W. Va.	38
106	Tygart Valley River	Below Tygart Reservoir	14
105	Tygart Valley River	Below Grafton, W. Va.	20
90	Big Sandy Creek	Rockville, W. Va.	5.0
94	Cheat River	Albright, W. Va.	25
95	Cheat River	Rowlesburg, W. Va.	15
401	Cheat River	Point Marion, Pa.	204
432	Redstone Creek	Below Uniontown, Pa.	5.7
433	Monongahela River	Brownsville, Pa.	469
434	Monongahela River	Millsboro, Pa.	448
425	Monongahela River	Pittsburgh, Pa.	462
429	Monongahela River	Wilson, Pa.	496
441	Monongahela River	Masontown, Pa.	360

Table 8 - Monongahela River basin streams
carrying more than five tons
per day net acidity (con't)

<u>Station No.</u>	<u>Stream</u>	<u>Location</u>	<u>Average Net Acid Load Tons/Day</u>
127	Monongahela River	Star City, W. Va.	235
128	Deckers Creek	Morgantown, W. Va.	5.3
129	Monongahela River	Hildebrand Lock and Dam	183
130	Monongahela River	Lock 15, Fairmont, W. Va.	118
402	Monongahela River	Point Marion, Pa.	221
403	Youghiogheny River	Above McKeesport, Allegheny County, Pa.	144
405	Sewickley Creek	Near mouth, Westmoreland County, Pennsylvania	21
410	Youghiogheny River	Below Connellsville, Pa.	28
415	Youghiogheny River	At Ohiopyle, Pa.	35
417	Casselman River	Below confluence of Whites Creek	30
419	Casselman River	At Markleton, Pa.	25
421	Casselman River	Below Piney Creek	5.1
424	Youghiogheny River	Below Youghiogheny Reservoir	7.0
447	Youghiogheny River	Above Jacobs, Pa.	26
3	Youghiogheny River	Below Little Youghiogheny River, Garrett Co., Maryland	10

acidity load of 29 tons per day. Other tributaries with significant acid loads were Tenmile Creek, Booth Creek, and Little Tenmile Creek. At its mouth near Fairmont, (Sta. 117) the West Fork River carried an average net acid load of 156 tons per day, had an average pH of 3.2, zero alkalinity, and an average sulfate concentration of over 1000 mg/l.

The Tygart Valley River basin has much less coal mining and mine drainage pollution sources than the West Fork River basin and therefore, contributes less acid to the Monongahela River. The Tygart Valley River is of good quality until it receives mine drainage from Roaring Creek in Randolph County. Further downstream in Barbour County, the Middle Fork and Buckhannon Rivers contribute some acid. Several small tributaries to the Buckhannon River in Barbour County carry relatively large amounts of acid. During the survey, the Tygart Valley River just below Philippi (Sta. 108) had a minimum pH of 4.8 during the study and the average net acid load was 2.7 tons per day. At a sampling station just below the Tygart Reservoir in Taylor County, (Sta. 106) the average net acid discharge was 14 tons per day and alkalinity concentrations were below desirable levels at all times. At Colfax near the mouth of the Tygart, (Sta. 104) the average net acidity load was 38 tons per day and the minimum pH was 4.7.

The Cheat River receives its first mine drainage pollution from the Blackwater River and its headwater tributaries in Tucker County, West Virginia. Just below Parsons, (Sta. 96) the Cheat River had a minimum pH of 6.7 and at Rowlesburg, Preston County (Sta. 95), the Cheat River had a minimum pH of 6.8. At Albright (Sta. 94) the net acid load in the Cheat River was 25 tons per day and the minimum pH was 4.8. This increase in acid loading and decrease in quality is from many small acid tributaries in central Randolph County. Acid streams such as Big Sandy Creek and Bull Run in the northern part of the County contribute additional acid to Cheat River. Big Sandy Creek at Rockville, W. Va. (Sta. 90) discharged 5.0 tons per day net acidity. The Cheat River at Point Marion, Pa., below Lake Lynn Reservoir (Sta. 401) discharged an average net acid load of 204 tons per day. The pH ranged from 2.9 to 4.2 and sulfate concentrations were as high as 2500 mg/l. Much additional acid is received by the Cheat from mine discharges in Fayette County, Pennsylvania.

The main stem Monongahela River at Fairmont, Marion County, W. Va., (Sta. 130) discharged 118 tons per day net acidity and the minimum pH was 3.9. Many minor tributaries such as Buffalo Creek, Paw Paw Creek, Scotts Run, and Deckers Creek contribute acid to the Monongahela River between Fairmont and Morgantown. The Monongahela at Star City (Sta. 127) discharged 235 tons per day net acidity and had a minimum pH of 3.4.

Below the mouth of the Cheat River, many tributaries, including Dunkard Creek, Tenmile Creek, and Redstone Creek discharge acidity to the Monongahela. At Wilson, Pennsylvania (Sta. 429), the Monongahela River carried an average load of 496 tons/day net acidity and had high concentrations of sulfate, iron, manganese, and hardness. The pH ranged between 5.2 and 6.1.

The Youghiogheny River, the largest tributary to the Monongahela in Pennsylvania, first receives some mine drainage pollution from a few small headwaters tributaries such as Snowy Creek in Garrett County, Maryland. The Youghiogheny River just below the Little Youghiogheny River near Oakland (Sta. 003) discharged 10 tons of acid per day. Neutralization of some of the acid in the Youghiogheny River decreased the load downstream, and near Friendsville, Maryland (Sta. 002) the Youghiogheny carried only 3.5 tons per day. Just below the Youghiogheny Reservoir in Pennsylvania (Sta. 424), the net acid load had increased to an average of 7.0 tons per day.

The Casselman River, tributary to the Youghiogheny River, is intermittently polluted by mine drainage in its headwaters in Garrett County, Maryland. Several small tributaries downstream from Salisburg, Pennsylvania, discharge acid to the River, and above Meyersdale, Pennsylvania, (Sta. 421) the net acid load carried was 5.1 tons per day. Between Meyersdale, Pennsylvania and Markleton, Pennsylvania (Sta. 419), other minor acid streams increased the net acidity load to 25 tons per day and the minimum pH was 3.6. The Casselman River near its mouth (Sta. 417) just below Whites Creek had a total average net acid load of 30 tons per day and the minimum pH was 4.5. At Ohiopyle, Somerset County, (Sta. 415) the Youghiogheny River carried an average net acidity load of 35 tons per day. This increase in acid load over that measured at the Youghiogheny Reservoir was received primarily from the Casselman River. Downstream below Connellsville, Pennsylvania, (Sta. 410) the net acid load was 28 tons per day.

Minor tributaries to the Youghiogheny River in Fayette, Westmoreland, and Allegheny Counties contributed some acid and produced intermittent stream pollution. Between Jacobs and McKeesport, Pennsylvania, several tributaries including Jacobs Creek and Sewickley Creek contributed additional mine drainage. Sewickley Creek near its mouth in Westmoreland County (Sta. 405) discharged an average of 21 tons per day of net acidity and had a minimum pH of 4.9. The Youghiogheny at its mouth at McKeesport, Pennsylvania, (Sta. 403) carried an average net acid load of 144 tons per day. The minimum pH was 4.8.

At Pittsburgh, Pennsylvania, (Sta. 425) the Monongahela River discharged a net acidity load of 462 tons per day to the Ohio River and had a minimum pH of 5.0.

Table 9 - Water quality data, Monongahela River basin

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
90	8	6.3 (6) 8.2 7.2	1.0 32.0 16.3	0.0 18.0 8.8	28.0 80.0 57.9	19.0 34.0 26.6	0.1 0.5 0.2	0.2 0.5 0.3 (5)*		4.2 992.0 196.6
94	12	3.4 6.5 4.8	15.0 86.0 34.3	0.0 3.0 0.9	32.0 96.0 71.8	22.0 85.0 53.8	0.3 2.8 1.1	0.0 0.3 0.1 (9)	0.3 (1)	26.0 1600.0 438.2
95	6	6.8 7.6 7.2	5.0 30.0 16.7	5.0 11.0 7.3	26.0 69.0 45.7	7.0 16.0 10.3 (3)	0.1 0.6 0.2	0.0 0.3 0.1 (4)		146.0 1762.0 870.7
96	12	6.7 9.0 7.4	0.0 47.0 11.9	4.0 26.0 13.3	26.0 74.0 55.1	3.0 40.0 25.0	0.0 1.0 0.3	0.0 0.3 0.1 (7)	0.4 (1)	48.0 1031.0 356.7
104	10	4.7 7.5 5.4	15.0 41.0 27.5	0.0 8.0 1.7	34.0 70.0 54.7	23.0 42.0 32.7	0.0 1.1 0.3	0.0 0.6 0.3 (9)		110.0 2640.0 653.7
105	1	7.3	30.0	5.0	52.0	16.0	0.2	0.3		445.0
106	2	6.8 7.2 7.0	27.0 33.0 30.0	1.0 2.0 1.5	44.0 60.0 52.0	16.0 17.0 16.5	0.2 0.4 0.3	0.3 0.6 0.5		120.0 250.0 185.0
108	12	4.8 7.4 6.1	12.0 39.0 23.1	0.0 45.0 7.2	42.0 112.0 76.0	19.0 92.0 57.0	0.0 1.3 0.4	0.0 0.8 0.4 (9)		16.7 2056.0 450.2

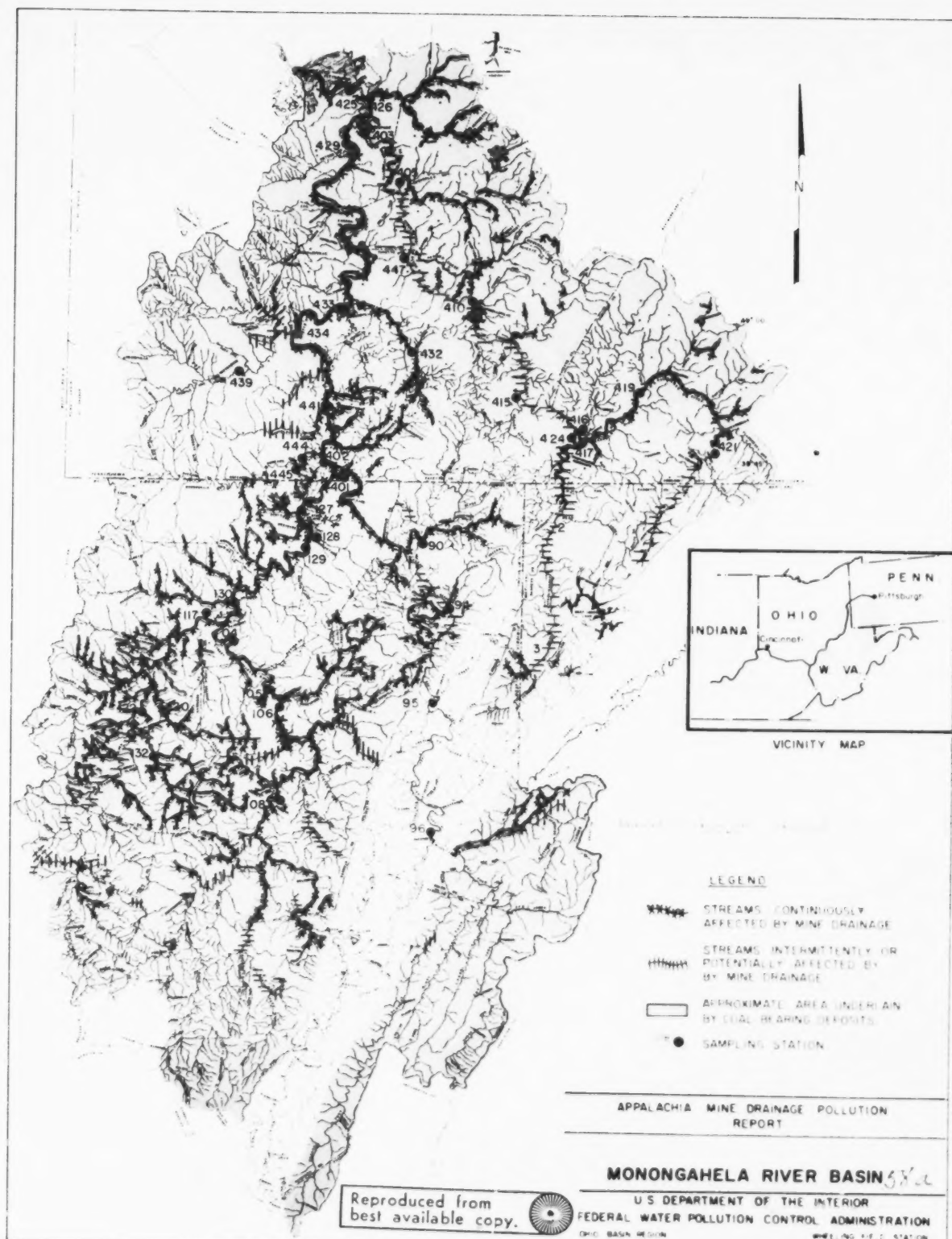
Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
117	12	2.9 3.5 3.2	17.0 362.0 216.6	0.0 0.0 0.0	100.0 1040.0 782.5	460.0 1400.0 1046.9	3.3 18.2 8.5	0.0 7.6 4.4		20.0 2400.0 353.7
120	9	2.8 3.1 3.0	300.0 418.0 366.7	0.0 0.0 0.0	708.0 1100.0 928.2	750.0 2750.0 1364.4	13.2 41.6 23.5	0.2 8.6 6.5		5.3 92.0 27.6
122	13	4.3 6.3 5.5	4.0 75.0 38.2	0.0 50.0 12.8	39.0 960.0 630.8	200.0 1300.0 686.2	0.7 7.8 2.8	1.6 5.1 3.0(9)		2.5 273.0 63.5
127	7	3.4 6.7 4.5	17.0 128.0 70.9	0.0 9.0 1.9	78.0 1104.0 367.4	80.0 900.0 371.3	1.7 10.4 3.3	0.4 2.2 1.4(4)		345.0 27500.0 5250.6
128	9	3.1 6.8 4.7	9.0 314.0 156.2	0.0 30.0 4.0	130.0 780.0 426.9	90.0 1225.0 534.1	2.8 10.3 6.8	0.6 6.8 2.6(6)	20.3(1)	0.1 348.0 90.3
129	12	3.3 6.7 4.1	14.0 115.0 74.7	0.0 9.0 0.8	100.0 360.0 230.2	86.0 1000.0 353.0	0.5 3.8 1.5	0.5 2.5 1.5(9)		205.0 26000.0 3068.3
130	12	3.9 6.2 4.8	12.0 116.0 55.3	0.0 8.0 1.5	112.0 326.0 197.6	60.0 450.0 198.2	0.4 5.0 1.5	0.4 2.4 1.3(9)		204.0 18200.0 2471.4
132	3	3.0 3.2 3.1	152.0 260.0 201.7	0.0 0.0 0.0	780.0 1120.0 903.3	660.0 1500.0 1011.7	5.0 15.4 9.5	6.1 8.1 6.9		6.5 18.5 11.4

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
401	10	Min. 2.9 Max. 4.2 Avg. 3.4	Min. 81.0 Max. 281.0 Avg. 133.7	Min. 0.0 Max. 0.0 Avg. 0.0	Min. 46.0 Max. 371.0 Avg. 139.0	Min. 56.0 Max. 2500.0 Avg. 430.7	Min. 1.3 Max. 16.4 Avg. 6.6	Min. 0.3 Max. 2.3 Avg. 1.0(6)	Min. 4.5 Max. 10.3 Avg. 7.4(2)	Min. 53.0 Max. 4000.0 Avg. 920.6
402	13	Min. 3.2 Max. 4.5 Avg. 3.6	Min. 13.0 Max. 179.0 Avg. 121.2	Min. 0.0 Max. 1.0 Avg. 0.2	Min. 84.0 Max. 500.0 Avg. 336.6	Min. 100.0 Max. 1250.0 Avg. 505.8	Min. 1.0 Max. 3.7 Avg. 2.3	Min. 0.4 Max. 3.3 Avg. 1.9(10)	Min. 410.0 Max. 2800.0 Avg. 990.0	
403	10	Min. 4.8 Max. 6.3 Avg. 6.0	Min. 10.0 Max. 52.0 Avg. 34.2	Min. 0.0 Max. 8.0 Avg. 4.3	Min. 100.0 Max. 180.0 Avg. 143.6(8)	Min. 72.0 Max. 190.0 Avg. 143.4(9)	Min. 1.4 Max. 6.0 Avg. 3.1(9)	Min. 0.3 Max. 1.0 Avg. 0.6(6)	Min. 720.0 Max. 4644.0 Avg. 1860.7	
405	2	Min. 4.9 Max. 5.0 Avg. 5.0	Min. 166.0 Max. 245.0 Avg. 205.5	Min. 3.0 Max. 9.0 Avg. 6.0	Min. 630.0 Max. 770.0 Avg. 700.0	Min. 795.0 Max. 1275.0 Avg. 1035.0	Min. 42.1 Max. 49.4 Avg. 45.8	Min. 3.4 Max. 4.0 Avg. 3.7	Min. 35.4 Max. 42.1 Avg. 38.8	
410	10	Min. 5.5 Max. 6.8 Avg. 6.4	Min. 7.0 Max. 36.0 Avg. 22.9	Min. 6.0 Max. 11.0 Avg. 8.6	Min. 62.0 Max. 88.0 Avg. 76.9(9)	Min. 20.0 Max. 74.0 Avg. 43.7	Min. 0.6 Max. 3.9 Avg. 1.4	Min. 0.0 Max. 1.4 Avg. 0.5	Min. 375.0 Max. 6200.0 Avg. 1718.0	
415	13	Min. 4.7 Max. 7.8 Avg. 6.7	Min. 5.0 Max. 37.0 Avg. 23.1	Min. 1.0 Max. 15.0 Avg. 7.5	Min. 44.0 Max. 80.0 Avg. 59.6	Min. 15.0 Max. 50.0 Avg. 28.7	Min. 0.0 Max. 1.7 Avg. 0.4	Min. 0.0 Max. 0.5 Avg. 0.3	Min. 560.0 Max. 2420.0 Avg. 968.5	
416	6	Min. 6.4 Max. 7.3 Avg. 6.9	Min. 5.0 Max. 26.0 Avg. 14.0	Min. 3.0 Max. 21.0 Avg. 13.5	Min. 32.0 Max. 56.0 Avg. 45.0	Min. 4.0 Max. 9.0 Avg. 6.7	Min. 0.0 Max. 1.0 Avg. 0.4	Min. 0.0 Max. 0.3 Avg. 0.1	Min. 14.5 Max. 460.0 Avg. 199.0	
417	10	Min. 4.5 Max. 6.0 Avg. 5.4	Min. 12.0 Max. 97.0 Avg. 46.0	Min. 0.0 Max. 35.0 Avg. 5.3	Min. 64.0 Max. 264.0 Avg. 162.3	Min. 61.0 Max. 210.0 Avg. 131.0	Min. 0.1 Max. 3.8 Avg. 0.9	Min. 0.3 Max. 2.7 Avg. 1.2	Min. 36.5 Max. 1560.0 Avg. 420.7	

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
419	9	3.6 6.2 4.7	10.0 120.0 70.9	0.0 4.0 0.6	76.0 318.0 197.1	51.0 470.0 210.1	0.0 2.2 0.8	0.0 2.5 1.5		37.8 1245.0 350.3
421	10	4.1 6.4 5.5	10.0 181.0 51.0	0.0 15.0 5.3	62.0 284.0 131.7(9)	39.0 310.0 91.8(9)	0.8 6.5 2.6(9)	0.0 3.3 0.8		4.8 405.0 122.4
424	10	5.8 7.2 6.5	4.0 35.0 18.2	6.0 18.0 11.0	24.0 46.0 37.9	8.0 20.0 11.7	0.2 0.8 0.5	0.0 0.7 0.2		92.5 1200.0 501.8
425	9	5.0 6.9 6.2	7.0 64.0 37.8(8)	0.0 9.0 6.0(8)	148.0 336.0 277.7(6)	66.0 470.0 281.4	0.8 15.8 3.1	0.4 1.9 1.3		1775.0 29050.0 8953.9
426	1	7.0	45.0	59.0	292.0	195.0	7.0	0.8		50.0
429	6	5.2 6.1 5.8	5.0 68.0 37.3	0.0 7.0 4.0	118.0 400.0 311.5(4)	80.0 550.0 296.2	0.8 8.5 2.6	0.4 2.9 1.3		842.0 31000.0 11303.7
432	9	6.1 6.6 6.3	11.0 500.0 247.3	15.0 67.0 41.3	210.0 1570.0 1175.8(8)*	210.0 2900.0 1548.3	14.8 434.6 156.6	1.6 12.4 7.2		11.6 560.0 86.9
433	10	3.6 6.2 4.6	6.0 180.0 94.2	0.0 4.0 0.7	110.0 460.0 282.7(9)	66.0 530.0 320.5	0.5 3.3 1.6	0.3 14.4 2.9		1000.0 21600.0 5876.0
434	9	3.6 6.3 4.8	5.0 575.0 138.0	0.0 5.0 1.0	82.0 400.0 264.5(8)	65.0 510.0 293.8	0.2 3.8 2.1	0.3 4.0 1.8		1000.0 16800.0 4172.2

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
439	Min.	6.9	2.0	5.0	98.0	25.0	0.5	0.1		2.0
	Max.	7.2	73.0	154.0	184.0	100.0	3.2	1.4		858.0
	Avg.	7.1	25.0	72.3	148.4(5)	50.7	1.1	0.8		257.1
441	Min.	3.1	6.0	0.0	68.0	40.0	2.0	0.4		402.0
	Max.	5.6	650.0	50.0	472.0	570.0	16.4	2.5		21300.0
	Avg.	4.0	177.7(7)	7.1(7)	224.7(7)	256.0	6.0	1.4(7)		5897.8
444	Min.	3.1	0.0	0.0	94.0	79.0	2.2	0.2		5.9
	Max.	7.5	535.0	82.0	820.0	1500.0	22.2	6.0		900.0
	Avg.	5.0	170.1	22.7	424.8(8)	646.9	11.2	2.0		147.4
445	Min.	6.4	0.0	26.0	78.0	51.0	0.2	0.0		1.7
	Max.	8.1	37.0	130.0	390.0	900.0	2.7	0.1		1800.0
	Avg.	7.2	12.2	67.5	220.4(5)	347.2	0.7	0.1		397.9
447	Min.	5.5	5.0	3.0	58.0	22.0	0.1	0.0		600.0
	Max.	8.8	34.0	14.0	232.0	77.0	4.2	1.4		6940.0
	Avg.	7.0	21.7	7.3	106.0(8)	52.1	1.1	0.4		2027.1

*() Indicates the number of samples used in averages when other than the maximum.



BEAVER RIVER

Description

The Beaver River basin is located in northeastern Ohio and northwestern, Pennsylvania. The Beaver River is formed by the confluence of the Mahoning River and Shenango River near New Castle, Pennsylvania, and flows in a southerly direction for about 21 miles, then enters the Ohio River at Beaver, Pennsylvania, which is 25 river miles below Pittsburgh, Pennsylvania. The Mahoning River rises south of Alliance, Ohio, flows northeast to Warren, Ohio, where it turns to the southeast and flows through Youngstown, Ohio and across the Ohio-Pennsylvania line to join the Shenango River. The Shenango River rises in Pennsylvania, flows northwest to the Ohio-Pennsylvania border and then flows generally south to the confluence with the Mahoning River. The total drainage area of the basin is 3,145 square miles encompassing parts of 13 counties in the two states.

Principal tributaries to the Beaver River are the Mahoning and Shenango Rivers and Connoquenessing, Slippery Rock, and Neshannock Creeks.

The Beaver River basin is situated in the Appalachian Plateaus province of the Appalachian Highlands physiographic division. The topography of the northern and western portions of the basin has been changed by the continental ice sheets, which rounded the hills and filled most of the bedrock valleys with thick deposits of glacial sediments. The southeastern part of the basin drained by Connoquenessing Creek is unglaciated and is a dissected plateau.

Industry in the Beaver River basin centers around the production of steel and the fabrication and finishing of steel products. In the Mahoning River watershed, major components of the industry are located in the Youngstown to Warren reach. The primary steel and fabricated steel products industries are important to all of the principal communities located in the Shenango River subbasin and on the Beaver River main stem. Principal communities in the basin and their 1960 populations are Youngstown, Ohio - 166,689; Warren, Ohio - 59,648; and New Castle, Pennsylvania - 44,790.

The Pennsylvania portion of the Beaver River basin, parts of seven counties, is contained within the Appalachian Region. The Ohio portion of the Beaver River basin is not included in the Appalachian Region.

Coal Reserves and Mining Activity

Recoverable bituminous coal reserves underlie three-fourths of the Beaver River basin and are estimated to be in excess of three billion tons. Of this total more than two-thirds of the reserve is in the Pennsylvania portion of the basin.

Coal production has been reported in all counties of the basin which contain reserves. Production for 1965 exceeded four million tons. Surface mining accounted for virtually all of the coal produced. (14) (19) (20).

Streams Affected and Present Quality

The Beaver River basin contains about 108 miles of streams polluted by acid mine drainage (Figure 5). The most seriously affected watershed in the basin is Slippery Rock Creek, which contains about 93 miles of acid polluted streams.

The Slippery Rock Creek drainage basin has had a long history of pollution resulting from mine drainage. Extensive deep mine activities were initiated in the early 1900's. Beginning with the early 1940's, the deep mining activity was followed by the onslaught of literally hundreds of strip mines. A 1963 survey of the Slippery Rock Creek watershed showed 935 active and inactive operations. Of this total, 590 of the operations were strip mines.

The large number of mines in the basin led to adverse effects on stream quality, but until 1958 the lower reaches of the stream were protected by the alkaline discharges from a limestone plant. When this plant ceased operations in late 1957, the stream became acid from its headwaters to the confluence with the South Branch. On July 12, 1964 an extremely heavy rainstorm fell in the upper, now acid, portion of the creek. This flushed out the acid water from swamps, strip mine pits, ponds, and the creek itself. As a result of this large amount of acid moving downstream, two million fish were killed. (21).

Based on various stream samplings during 1966 (Table 10) the North Branch of Slippery Rock Creek (Sta. 482) discharged an average net acid load of 8.6 tons per day and the pH ranged from 2.7 to 5.0. The South Branch of Slippery Rock Creek (Sta. 483) was alkaline during the survey but carried high concentrations of some mine drainage indicators. Further downstream, Station No. 481, the average acidity load in Slippery Rock Creek had decreased to an average level of 5.0 tons per day in excess of the alkalinity. Above the confluence of Wolf Creek (Sta. 480) Slippery Rock Creek showed further decreases in net acidity.

Wolf Creek above Grove City receives some mine drainage but this was rapidly neutralized during travel downstream. At the mouth of Wolf Creek (Sta. 477), the net alkalinity load averaged 28 tons per day and the minimum pH was 6.8. The alkalinity carried by Wolf Creek neutralized the acidity in Slippery Rock Creek at that point and the net alkalinity at Station No. 476 was 30 tons per day.

Muddy Creek also receives some acid mine drainage but during the survey, Station No. 484, at the mouth of Muddy Creek, exhibited a pH range of 6.3 to 7.4 and the average alkalinity concentration exceeded the average acidity concentration.

Near its mouth (Sta. 475), Slippery Rock Creek had a pH range of 6.9 to 8.3 and an average net alkalinity load of 26 tons per day.

Little Connoquenessing Creek receives some acid drainage as a result of coal mining operations. Alkalinity loads always exceeded acidity loads during the study period but the presence of mine drainage was indicated by high concentrations of iron, sulfate, and hardness (Sta. 471).

Mine drainage problems in the Beaver River basin are not limited to the Pennsylvania portion of the basin. There are several streams in Mahoning County, Ohio, though not continuously polluted by mine drainage, which have experienced washouts of acid mine water. A washout, occurring in January, 1965, resulted in a fish kill of 1,600 along a tributary to Meander Creek.

Table 10 - Water Quality Data, Beaver River basin

Map Station No.	No. of Samples	pH	Acidity (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	Sulfate (mg/L)	Total Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Flow (cfs)
471	9	6.5 7.6 7.1	0.0 34.0 9.3	17.0 53.0 31.3	90.0 326.0 205.1	50.0 560.0 188.0(8)*	0.0 4.2 1.3	0.2 1.4 0.8	0.0 3.0 1.0(6)	1.9 340.0 79.0
475	9	6.9 8.3 7.6	0.0 16.0 4.3	21.0 92.0 62.8	114.0 253.0 196.9	82.0 165.0 132.4	0.0 4.2 0.9	0.0 2.3 0.7	0.4 6.0 1.5(6)	0.4 2240.0 513.4
476	9	6.6 7.8 7.1	0.0 21.0 6.9	21.0 75.0 45.4	114.0 233.0 176.7	72.0 175.0 127.9	0.0 2.9 0.7	0.0 2.5 0.9	0.0 6.1 1.6(6)	110.0 2460.0 586.9
477	6	6.8 7.8 7.3	0.0 25.0 9.8	48.0 79.0 62.0	130.0 236.0 164.8	48.0 140.0 94.8	0.3 0.7 0.5	0.2 0.8 0.4	0.4 1.0 0.6(3)	57.0 222.4 109.5
478	9	7.1 8.5 7.5	0.0 29.0 10.9	36.0 111.0 68.6	112.0 281.0 184.7	38.0 160.0 100.5(8)	0.0 2.4 0.9	0.3 1.3 0.7	0.0 7.5 1.6(6)	22.0 540.0 114.4
479	3	6.9 7.0 6.9	15.0 49.0 27.7	22.0 38.0 31.3	66.0 128.0 104.7	33.0 80.0 60.3	0.4 2.1 1.1	0.6 1.3 1.0	0.5 6.9 2.9(6)	55.0 290.0 165.0
480	9	4.3 7.2 6.2	0.0 55.0 19.8	0.0 45.0 15.4	128.0 279.0 201.9	85.0 240.0 176.1	0.3 1.8 0.9	1.0 3.1 2.1	0.5 6.9 2.9(6)	16.7 448.2 149.6
481	3	6.6 7.0 6.7	11.0 27.0 16.7	8.0 15.0 10.7	116.0 180.0 150.7	90.0 140.0 120.0	0.4 1.0 0.7	1.3 2.1 1.7	1.3 2.1 1.7	185.0 356.0 288.7

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
482	Min.	2.7	24.0	0.0	132.0	110.0	0.2	1.0	1.8	8.9
	Max.	5.0	153.0	10.0	312.0	390.0	40.0	3.4	14.0	164.0
	Avg.	4.3	60.1	3.8	217.1	226.1	8.0	2.6	7.8(6)	64.5
483	Min.	6.7	0.0	22.0	116.0	73.0	0.2	1.0	0.1	2.3
	Max.	7.2	22.0	78.0	333.0	270.0	7.9	3.1	17.2	100.0
	Avg.	6.9	7.0	39.2	223.6	172.4	1.7	1.4	3.1(6)	31.3
484	Min.	6.1	0.0	8.0	110.0	77.0	0.1	0.4	0.0	2.0
	Max.	7.4	28.0	67.0	358.0	310.0	1.3	3.4	2.5	330.0
	Avg.	6.6	11.0	24.9	215.4	182.7	0.6	1.7	1.1(6)	81.3
654	Min.	7.8	0.0	32.0	113.0	115.0	0.1	0.1	0.2	0.1
	Max.	10.6	3.0	245.0	176.0	156.0	0.4	5.2	2.2	12.0
	Avg.	9.8	0.5	117.8	140.2	131.8	0.3	1.2	1.1(3)	3.5

*(8) Indicates the number of samples used in averages when other than the maximum.

MUSKINGUM RIVER

Description

The Muskingum River basin lies in the eastern part of the State of Ohio. It is bounded by the Scioto River drainage on the west, Lake Erie drainage on the north, and the Ohio River minor tributary drainage on the east and south. The Muskingum River is formed by the junction of its two principal tributaries, the Tuscarawas and Walhonding Rivers, at Coshocton near the center of the basin. The Tuscarawas River and its tributaries rise near Barberton in the northwestern part of the basin. The Walhonding River and its tributaries rise near Ashland in the northeastern part of the basin. The Muskingum flows south for about 110 miles and enters the Ohio River at Marietta, Ohio, 172 miles below Pittsburgh, Pennsylvania. The total drainage area of the basin is 8,040 square miles, about 20 percent of the land area of the State, and covers all or part of 27 counties. The basin is roughly rectangular in shape, about 120 miles long in the north-south direction, and about 100 miles wide in the east-west direction. The principal tributaries comprising the Muskingum River system are the Walhonding, Tuscarawas, and Licking Rivers, and Wills Creek.

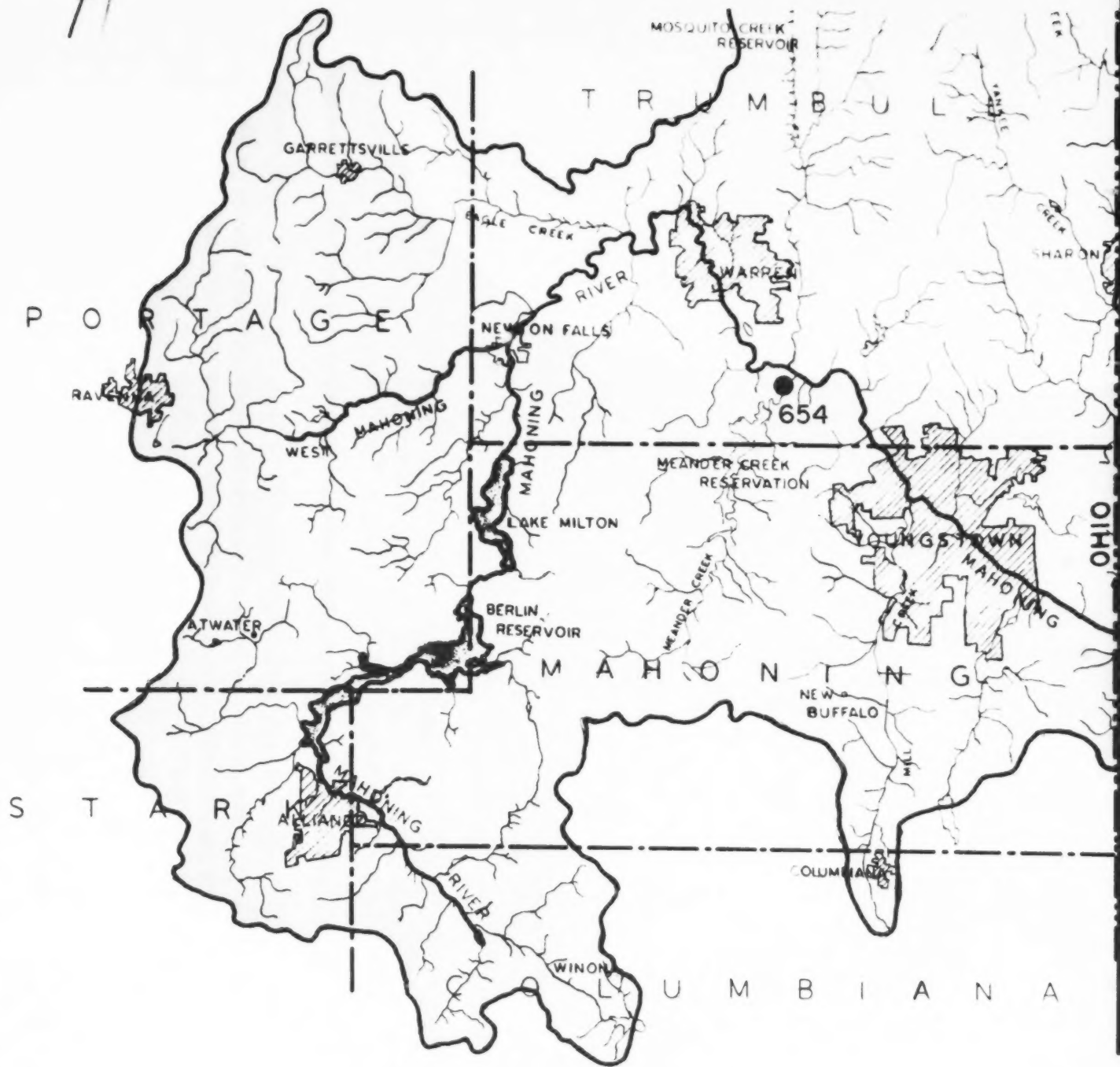
The northern and western portions of the watershed were covered by Pleistocene glaciers. The line of glaciation generally trends east to west from Canton to Loudonville, and thence almost directly south leaving the basin in Perry County. The glaciated area is characterized by gently rolling to flat topography. The unglaciated area is generally rugged and well dissected by drainage. Broad valleys with prominent flood plains and terraces characterize the larger streams in the unglaciated area. The glaciers changed the drainage of every major stream in the basin, and outwash materials filled the major valleys many miles below the ice fronts.

Extensive and diverse industrial activities are centered in the Canton-Massillon, Mansfield, Newark, Zanesville, Barberton, Ashland, Wooster and Cambridge areas. Agriculture, coal mining, oil production, and salt and clay mining also maintain important positions in the economy of the basin. The principal cities in the basin and their 1960 populations are Canton - 113,631; Mansfield - 47,325; Newark - 41,790; Zanesville - 39,077; Barberton - 33,805; and Massillon - 31,236.

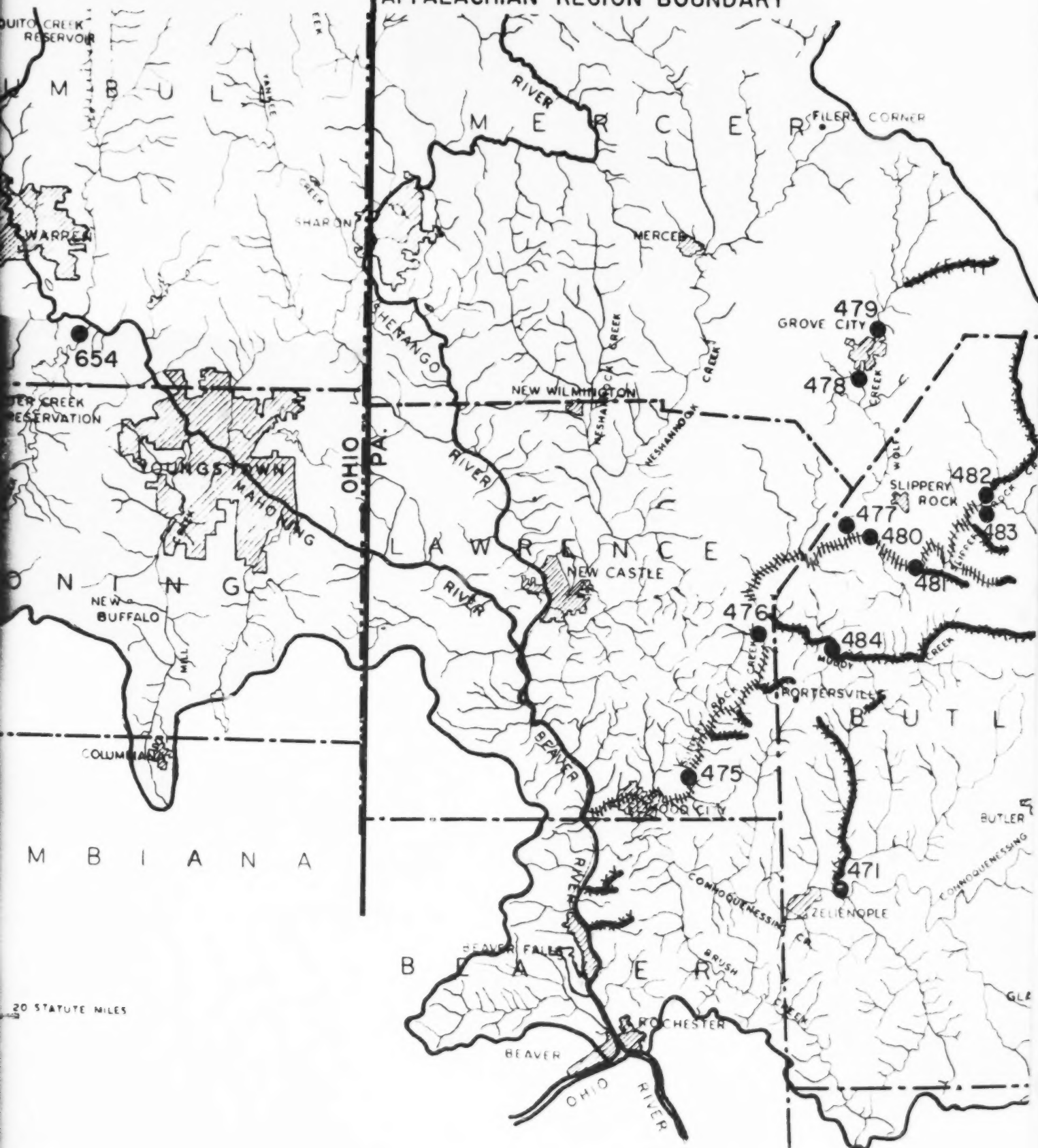
About one-half of the Muskingum basin is located in the Appalachian Region. Only the counties or portions of eleven counties making up the western and northern boundaries of the basin are excluded.

A

B



APPALACHIAN REGION BOUNDARY





VICINITY MAP

LEGEND

- STREAMS CONTINUOUSLY AFFECTED BY MINE DRAINAGE
- STREAMS INTERMITTENTLY OR POTENTIALLY AFFECTED BY MINE DRAINAGE
- APPROXIMATE AREA UNDERLAIN BY COAL-BEARING DEPOSITS
- SAMPLING STATION

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APPALACHIA MINE DRAINAGE POLLUTION
REPORT

BEAVER RIVER BASIN

644

U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION WHEELING FIELD STATION

FIGURE 5

Coal Reserves and Mining Activity

Bituminous coal reserves in the Muskingum basin are present in 21 of the 27 Ohio counties that are wholly or partly contained in the watershed, amounting to 80 percent of the area. Coal production has been reported from all but one of the 21 counties containing reserves. Recoverable coal reserves in the Muskingum River basin portion of these counties is estimated at over eight billion tons.

The Muskingum basin has a long history of coal production, and prospects for long-term continued production are excellent in view of recent industrial expansion in the area. Six of the basin counties had a cumulative coal production of over 100 million tons during the period 1800-1958. Production in 1965 in the watershed amounted to nearly 19 million tons, about 70 percent by surface mining methods. (19) (20).

Streams Affected and Present Quality

Although some mine drainage pollution occurs in each of the coal producing counties of the basin, Tuscarawas, Coshocton, Muskingum, and Perry Counties are the most seriously affected in terms of number of streams and total length of streams affected (Figure 6). With very minor exceptions, all affected streams in the basin are within the Appalachian Region. A total of more than 500 miles of streams in the watershed are considered to be polluted by mine drainage. Table 11 presents the miles of streams found by this survey to be polluted by mine drainage.

Table 11

Lengths of streams polluted by
mine drainage, Muskingum River basin

<u>Stream</u>	<u>Drainage Area</u>	<u>Continuously Polluted (Miles)</u>	<u>Inter- mittently Polluted (Miles)</u>	<u>Total</u>
Muskingum River	8038			
Tributaries		244	59	303
Tuscarawas River	2590			
Tributaries		154	34	188
Walhonding River	2252			
Tributaries		16	15	31
		<u>414</u>	+ <u>108</u>	= <u>522</u>

Water quality data gathered during 1966 and 1967 (Table 12) shows that, although many smaller streams in the Muskingum watershed are affected, mine drainage effects on the principal streams are minor. The presence of other industrial pollutants and the large dilution and neutralization factors provided largely masks the quality changes caused by mine drainage.

The following fish kills resulting from acid mine drainage were reported in the Muskingum River basin during 1966:

<u>Date</u>	<u>County</u>	<u>Watershed</u>	<u>No. of Fish Killed</u>
8/12/66	Perry	Jonathan Creek	5000
8/21/66	Coshocton	Mill Creek	3061
8/31/66	Tuscarawas	Sugar Creek	50,670
9/22/66	Muskingum	Muskingum River	20,860

Most of the coal mine drainage flowing into the Tuscarawas River enters in the reach between Massillion and Newcomerstown. Industrial pollution originating in the Akron area affects the Tuscarawas River to such a degree that the influence of the mine drainage that enters the river below Massillion is not easily recognizable. The effect of mine drainage is, however, reflected in loadings of mine drainage pollution indicators. The average sulfate loading was 142 tons/day at station 719 above Massillion and 250 tons/day at station 727 above Newcomerstown. The average iron loadings were 0.3 tons/day and 2 tons/day at these respective stations.

The small amount of mine drainage entering the Walhonding River is contributed by tributaries entering in the lower 10 miles of the river. These sources and tributaries entering the Muskingum immediately below Coshocton do not significantly affect the quality of the Muskingum, but are evidenced by increased loadings of mine drainage indicators, such as sulfate, hardness, and iron.

In the lower Muskingum basin, Moxahala Creek and its tributaries in Perry and Muskingum Counties are the most seriously polluted streams from acid mine drainage in the Muskingum basin. Ninety miles of streams in this small watershed are affected. A survey conducted by the Wheeling Field Station in 1963 showed Moxahala Creek to be highly acidic over most of its length and discharging 16,400 pounds per day of acid to the Muskingum River. Readings of pH as low as 2.7 were observed in stream waters during the survey. Limited field work conducted this year in the Moxahala watershed indicates there may be more than 200 significant point sources of mine drainage polluting the streams of the watershed.

Table 12 - Water quality data, Muskingum River basin

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
1715	9	7.3	0.0	93.0	126.0	52.0	0.2	0.2	0.7	18.1
		7.7	10.0	201.0	228.0	136.0	3.8	1.0	3.1	687.0
		7.5	1.3(8)*	161.4(8)	162.1(8)	67.9	1.7	0.5	1.6(6)	211.0
1716	9	7.1	0.0	69.0	106.0	9.0	0.4	0.1	0.6	10.0
		7.6	24.0	194.0	156.0	35.0	0.7	0.3	1.3	38.0
		7.3	4.1	97.9	132.2	21.3(8)	0.6	0.2	0.9(6)	21.0
1717	12	6.4	0.0	26.0	49.0	25.0	0.4	0.1	0.7	0.0
		7.7	28.0	148.0	236.0	105.0	5.9	7.2	1.3	150.4
		7.1	10.6	83.4	141.5	67.7	1.3	1.4	1.0(5)	45.1
1718	9	6.8	0.0	74.0	327.0	160.0	1.0	0.2	1.6	890.0
		8.0	39.0	120.0	432.0	240.0	2.5	3.3	3.4	3027.0
		7.4	12.7	100.1	390.2	190.3	1.6	1.3	2.3(6)	1573.6
1719	14	6.3	16.0	79.0	295.0	35.0	0.2	0.0	0.4	75.0
		8.3	129.0	216.0	3000.0	2500.0	3.6	0.3	19.6	847.0
		7.5	64.5	145.3	1752.4	443.8(13)	1.0(13)	0.1(13)	4.3(6)	254.9
1720	15	7.0	0.0	98.0	198.0	20.0	0.0	0.3	0.0	62.3
		7.8	99.0	302.0	474.0	500.0	5.0	1.4	1.6	500.0
		7.5	13.4	302.0	292.9	240.9	2.1	0.9	0.9(7)	144.1
1721	9	6.9	0.0	89.0	222.0	132.0	0.2	0.1	0.5	980.0
		7.9	45.0	127.0	428.0	215.0	1.2	0.6	2.2	2600.0
		7.7	11.9	105.6	346.8	179.8	0.5	0.3	0.9(6)	1647.2
1722	9	7.0	0.0	12.0	126.0	110.0	0.5	0.3	1.0	800.0
		8.6	32.0	148.0	428.0	220.0	2.3	1.2	2.0	2410.0
		7.9	7.7	104.1	343.4	168.1	1.0	0.8	1.4(6)	1318.0

Map Station No.	Nc. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
1723	9	7.2 8.1 7.7	0.0 43.0 10.8	16.0 187.0 140.0	133.0 420.0 216.2	56.0 425.0 107.8	0.4 1.4 0.9	0.2 1.1 0.5	0.0 2.2 1.0(6)	87.0 348.0 167.4
1724	9	6.7 7.5 7.1	0.0 28.0 7.0	0.0 86.0 61.9	140.0 375.0 273.3	110.0 310.0 253.9	0.4 10.8 2.4	0.9 5.4 2.2	0.6 4.9 2.1(6)	30.0 264.0 77.8
1725	9	6.8 7.4 7.2	0.0 82.0 18.4	47.0 89.0 73.9	140.0 263.0 199.8	60.0 223.0 122.8	0.2 1.8 0.6	0.2 13.8 2.9	0.5 2.0 1.2(6)	28.0 75.5 46.7
1726	4	6.9 7.1 7.0	0.0 27.0 11.5	90.0 131.0 108.5	431.0 624.0 548.8	440.0 565.0 503.8	0.9 1.4 1.2	0.8 1.2 1.0	0.3 1.4 0.9(3)	0.0 0.0 0.0
1727	12	6.5 8.6 7.3	0.0 68.0 17.9	41.0 150.0 80.5	242.0 804.0 516.4	110.0 320.0 194.6	0.5 3.9 2.2	0.8 2.0 1.3	0.7 5.2 2.0(5)	295.0 9800.0 2357.6
1728	14	6.9 8.2 7.4	0.0 43.0 11.1	38.0 123.0 83.6	168.0 429.0 319.2	120.0 4750.0 572.7	0.4 2.0 1.0	0.4 12.2 3.3	0.1 2.0 1.1(7)	9.1 830.0 145.8
1729	15	6.9 8.1 7.4	0.0 54.0 10.5	23.0 137.0 85.2	83.0 440.0 211.1	68.0 200.0 123.9	0.2 4.5 2.1	0.2 1.5 0.7	0.7 2.2 1.4(7)	28.0 1420.0 272.5
1730	8	7.5 8.2 7.7	0.0 42.0 7.1	151.0 224.0 182.3	44.0 170.0 117.0	25.0 54.0 39.4	0.0 0.5 0.2	0.2 0.7 0.3	0.0 0.8 0.5(5)	0.1 12.3 3.1

Map Station No.	Min. Max. Avg.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total			Flow (cfs)
								Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	
1731		9	7.1	0.0	105.0	106.0	40.0	0.2	0.0	0.6	281.0
			8.2	56.0	158.0	209.0	75.0	1.4	0.5	2.5	2480.0
			7.8	6.2	137.7	164.9	57.7	0.7	0.2	1.2(6)	941.0

*(8) Indicates the number of samples used in averages when other than the maximum.

HOCKING RIVER

Description

The Hocking River basin embraces an area of 1,200 square miles located in the hill section of southeastern Ohio. The basin is long and narrow in shape having a length to width ratio of about three to one. The axis of the basin is oriented NW-SE and is about 65 miles in length. The basin is bounded on the north by the Muskingum River drainage basin, on the west by the Scioto River basin, and on the south by Raccoon Creek, Leading Creek, and the Shade River drainage basins. The basin includes portions of Fairfield, Perry, Hocking, Morgan, Athens, Meigs, and Washington Counties.

The Hocking River area is located in the Kanawha Section of the Appalachian Plateaus physiographic province. This section represents a mature plateau of fine texture with moderate to strong relief. With the exception of the uppermost part in Fairfield, Perry and Hocking Counties, the basin lies in the unglaciated portion of Ohio. Generally, the valleys are narrow and the hillsides are steep and abrupt. The divides are ridge-like, separating streams arranged generally in a dendritic pattern. The Hocking River heads in Fairfield County in the northwestern portion of the basin. The stream extends approximately 95 miles in a relatively straight line in a southeastward direction to its confluence with the Ohio River, about 15 miles below Parkersburg, West Virginia. The river has an average gradient of 4.6 feet per mile. Principal tributaries in the Hocking watershed include Rush Creek, Sunday Creek, Monday Creek, and Federal Creek.

The principal communities in the Hocking River basin are Athens, Lancaster, Logan, and Nelsonville. All of these communities are located on the main stem Hocking River.

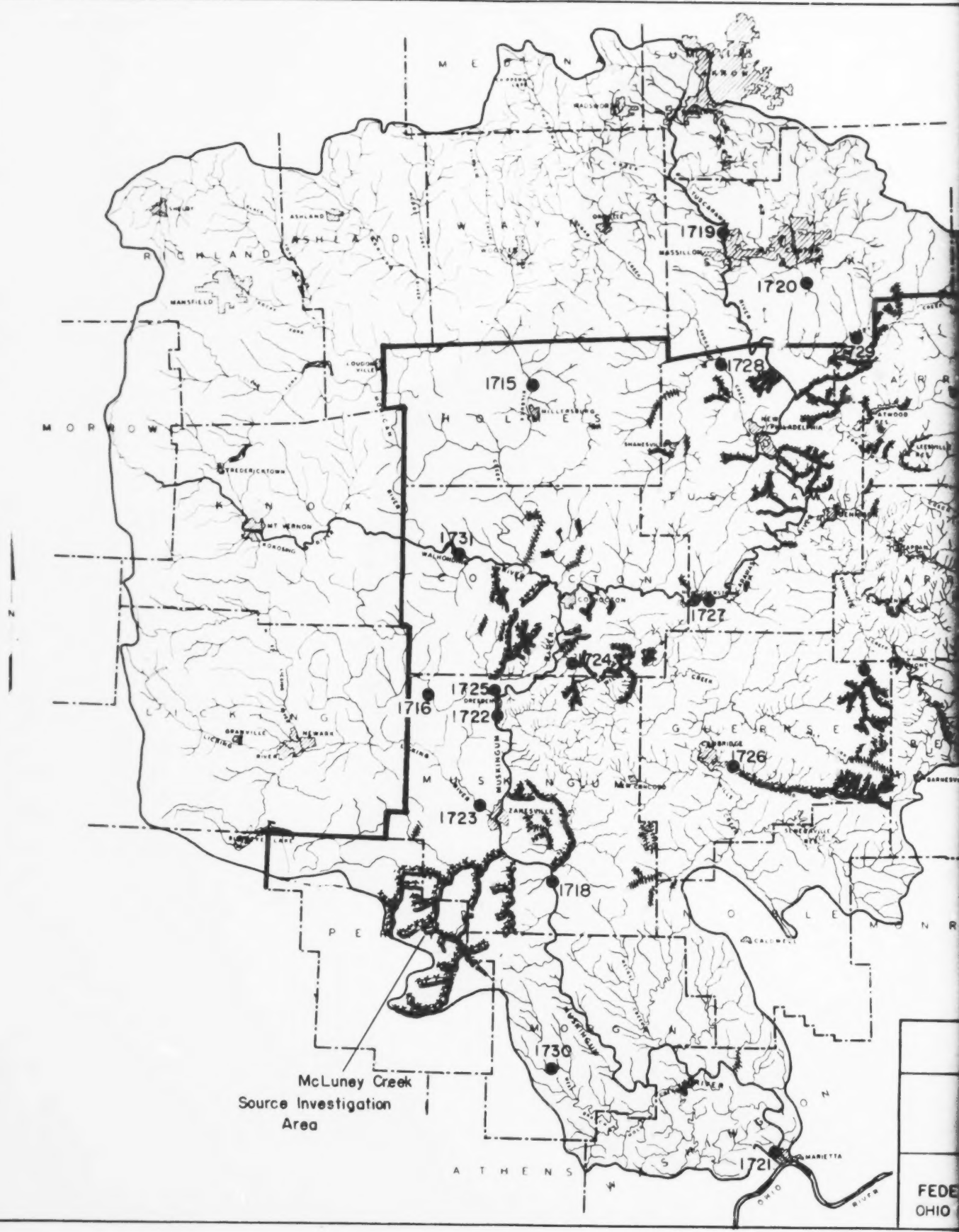
The principal industries in the Hocking River basin are centered chiefly in the two largest cities, Lancaster and Athens. The principal industries are engaged in the manufacture of stone, clay, glass products, electrical machinery products, printing and publishing products, and fabricated metal products.

Of the six counties in the Hocking River basin, all but Fairfield County, in the northwest corner of the watershed, are in the Appalachian Region.

Coal Reserves and Mining Activity

Bituminous coal reserves in the Hocking River basin are present

A



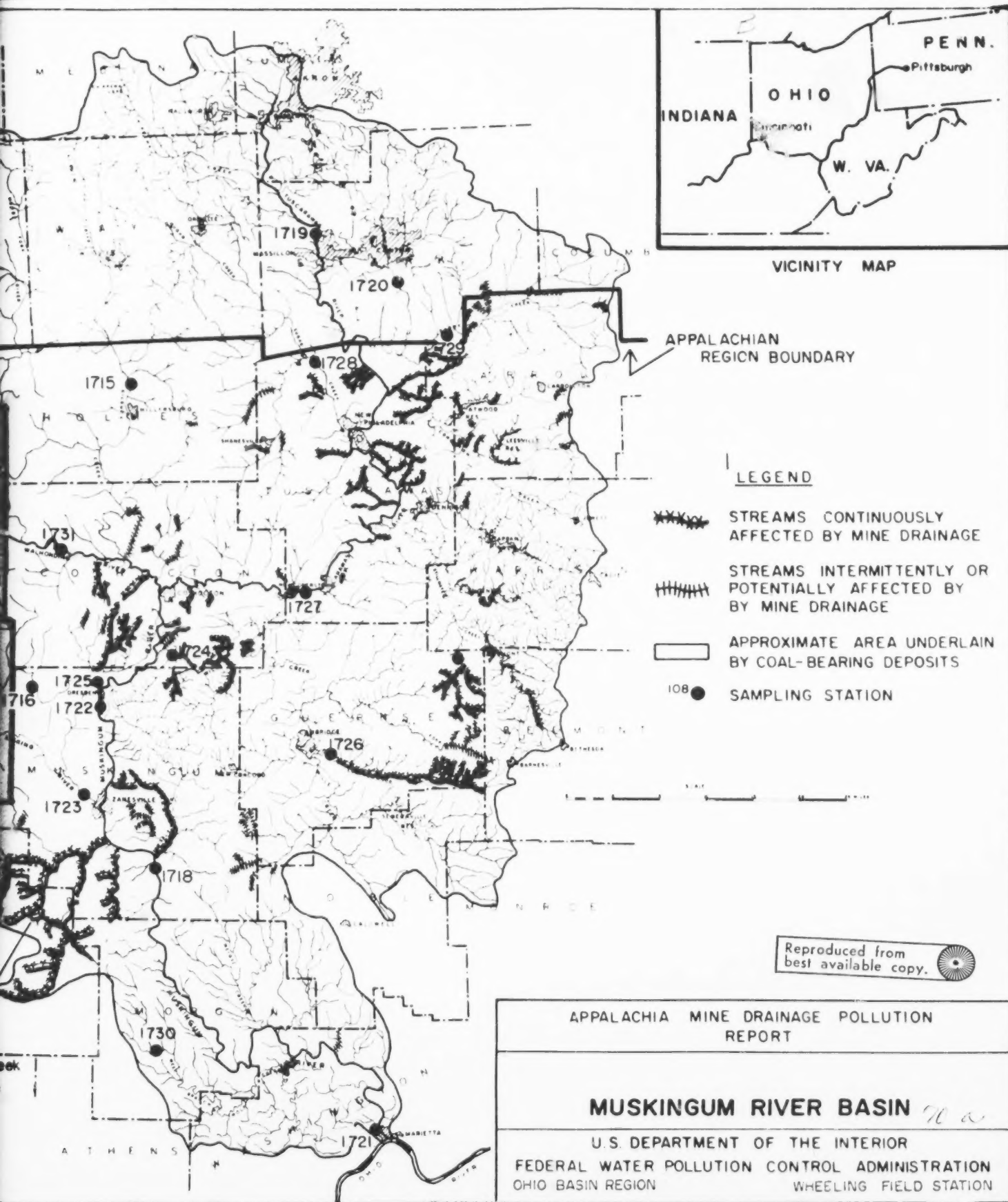


FIGURE 6

in five of the six counties that make up the watershed, amounting to three-quarters of the area. Coal production has been reported in all of the counties containing reserves. Production in 1962 amounted to more than 900,000 tons but this tonnage increased to over 1.6 million in 1965. Surface mine operations accounted for approximately 80 percent of the total coal production figures in 1965.

The recoverable reserve of coal within the boundaries of this drainage area is estimated at over one billion tons. This tonnage represents substantial potential for continued and expanded coal production in the Hocking River basin (19) (20).

Streams Affected and Present Quality

The Hocking River basin contains 364 miles of streams significantly polluted by coal mine drainage, 223 miles of which are continuously polluted and 141 miles of which are intermittently polluted. The principal problem areas are found in Athens, Hocking, and Perry Counties (Fig. 7 and Table 13).

Major tributaries to the Hocking River polluted by coal mine drainage are Rush Creek, Monday Creek, Sunday Creek, and Federal Creek. At its midpoint (Sta. 1696) Monday Creek carried an average net acidity load of 5.6 tons per day, had a pH range of 3.1 to 3.6, and had high concentrations of sulfate, metals and hardness. At its mouth (Sta. 1690) the acidity load in Monday Creek increased to 19 tons per day, the pH ranged from 2.8 to 3.3, and other mine drainage indicators were present in high concentrations. Alkalinity was continually absent at both locations.

At its confluence with Sunday Creek (Sta. 1698), the West Branch of Sunday Creek carried an acidity load of 4.2 tons per day, exhibited a pH range of 2.9 to 4.2, and had high concentrations of sulfate, metals, and hardness. Sunday Creek carried an average net acid load of 13 tons per day at its mouth (Sta. 1691) and had high concentrations of mine drainage indicators.

Rush and Federal Creeks receive mine drainage throughout their watersheds, but are alkaline at their mouths. The level of mine drainage pollution in these streams is indicated by the concentrations of sulfate, metals and hardness as measured at stations 1689 and 1699.

Table 13 - Water quality data, Hocking River basin

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
689	Min.	5.8	0.0	10.0	75.0	75.0	0.2	1.6	0.0	36.0
	Max.	7.4	35.0	72.0	545.0	450.0	6.6	13.8	11.1	870.0
	Avg.	6.3	11.0	39.2	324.0	243.3	2.1	8.0	4.4	185.3
690	Min.	2.8	175.0	0.0	219.0	260.0	4.8	8.3	25.7	8.0
	Max.	3.3	597.0	0.0	1480.0	875.0	43.2	12.2	138.9	43.5
	Avg.	3.1	438.8	0.0	571.8	572.5	20.2	10.1	64.5	16.6
691	Min.	2.6	0.0	0.0	110.0	95.0	3.5	0.0	0.9	10.7
	Max.	6.2	712.0	32.0	780.0	1175.0	168.0	13.8	86.2	90.0
	Avg.	3.3	400.3	5.3	562.0	503.3	64.9	9.0	44.8	26.1
693	Min.	6.5	0.0	55.0	58.0	14.0	0.4	0.0	0.0	10.0
	Max.	7.9	9.0	296.0	290.0	120.0	7.6	0.3	10.6	304.0
	Avg.	7.3	1.5	223.3	180.2	74.8	2.2	0.2	4.3	62.1
694	Min.	6.6	0.0	30.0	104.0	80.0	0.3	1.3	0.9	92.0
	Max.	7.6	28.0	113.0	460.0	340.0	4.8	13.8	20.7	7600.0
	Avg.	6.9	5.3	74.7	368.0	236.7	1.7	5.1	5.3	1398.3
695	Min.	6.4	0.0	24.0	94.0	85.0	0.3	0.2	1.5	120.0
	Max.	7.7	25.0	90.0	430.0	340.0	6.2	4.4	6.8	7500.0
	Avg.	7.1	6.8	71.5	307.8	201.7	1.7	1.0	3.2	1417.5
696	Min.	3.1	107.0	0.0	455.0	164.0	3.6	8.2	6.4	2.2
	Max.	3.6	364.0	0.0	1044.0	580.0	12.0	13.8	66.6	15.0
	Avg.	3.4	248.7	0.0	675.0	419.0	6.7	11.0	27.1	7.6

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
697	Min.	7.0	0.0	84.0	64.0	24.0	0.2	0.0	0.0	13.0
	Max.	8.2	0.0	187.0	267.0	37.0	5.3	1.6	7.9	312.0
	Avg.	7.6	0.0	143.7	149.6(5)*	31.7	1.2	0.6	1.9	66.3
698	Min.	2.9	125.0	0.0	250.0	330.0	16.8	3.9	3.7	3.5
	Max.	4.2	446.0	0.0	945.0	1225.0	72.0	13.8	123.8	12.2
	Avg.	3.2	315.8	0.0	696.0	740.8	49.7	11.0	54.6	5.7
699	Min.	5.0	0.0	1.0	168.0	120.0	0.0	0.3	0.2	0.0
	Max.	7.7	100.0	142.0	620.0	265.0	1.0	3.3	6.7	110.0
	Avg.	6.7	23.5	86.2	323.8	210.8	0.6	1.3	3.5	18.6

*(5) Indicates the number of samples used in averages when other than the maximum.

LITTLE KANAWHA RIVER

Description

The Little Kanawha River basin embraces 2,309 square miles of west-central West Virginia, lies entirely within the State, and comprises nearly 10 percent of the area of the State. The basin is 80 miles in length, and its maximum width is about 50 miles. It is bounded on the south by the Kanawha River basin, on the west by the Ohio River, on the north by the Middle Island Creek basin, and on the east by the Monongahela River basin. The basin contains all or part of 12 West Virginia counties. The Little Kanawha River heads in southwestern Upshur County and flows 165 miles to the northwest to its mouth at Parkersburg, West Virginia, 185 river miles below Pittsburgh, Pennsylvania. From the headwaters to a point 44 miles downstream, the river has a fall of about 29.5 feet per mile. The rate of fall for the remaining 121 miles is only about 1.5 feet per mile. The principal tributary to the Little Kanawha is the Hughes River.

The Little Kanawha River basin is located in the Kanawha section of the Appalachian Plateaus physiographic province. The basin exhibits the steep slopes, sinuous ridges, and fine dissection characteristic of this section. Flat land is mostly absent except along the lower reach of the river where broad flood plains and terraces make up the topography. Parkersburg, West Virginia, is located on the flat land near the confluence of the Little Kanawha and Ohio Rivers. The topography of the basin is rugged throughout with elevations in the headwaters reaching approximately 2,200 feet. The normal pool elevation at the mouth of the basin is 572 feet, giving a total relief of about 1,630 feet.

The major sources of income in the basin are derived from agriculture, manufacturing, and mining. Also, with 60 percent of the area in commercial forest land, timber extraction is important to the area's economy. Nearly 90 percent of farm production is livestock and livestock products. Coal is the most valuable mineral resource in the basin, but most of the increased economic activity in the mining industry comes from an expansion of gas and oil production. Most of the industrial and commercial activity is in Wood County with Parkersburg, located on the main stem Ohio River, as the principal manufacturing community. The principal communities and the 1960 populations are Spencer - 2,660; Glenville - 1,828; Pennsboro - 1,660; and, Harrisville - 1,428. Parkersburg, at the mouth of the basin, had a 1960 population of 44,797.

All of the Little Kanawha River basin is contained in the Appalachian Region.

APPALACHIAN REGION BOUNDARY



Sunday Creek
Source Investigation Area

SCALE

M E I G S

0 5 10 15 20 25 MILES

UNDARY

Sunday Creek
Source Investigation Area

N

R Y
PITTSBURGH



VICINITY MAP

LEGEND

- STREAMS CONTINUOUSLY AFFECTED BY MINE DRAINAGE
- STREAMS INTERMITTENTLY OR POTENTIALLY AFFECTED BY MINE DRAINAGE
- APPROXIMATE AREA UNDERLAIN BY COAL-BEARING DEPOSITS
- 108 ● SAMPLING STATION

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APPALACHIA MINE DRAINAGE POLLUTION
REPORT

HOCKING RIVER BASIN

74 a

U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION WHEELING FIELD STATION

Coal Reserves and Mining Activity

Bituminous coal reserves are present in seven of the 12 counties which are wholly or partly contained in the basin. The area underlain by mineable coal reserve amounts to about 60 percent of the total land area of the watershed. The area underlain by coal is roughly that basin area upstream of the western edge of Gilmer County. The recoverable coal reserve of the Little Kanawha River basin portion of these counties is estimated to be about two billion tons.

Although the watershed contains an appreciable coal reserve, the resource has not been extensively tapped. The coal removed over the years in this area has been mostly for domestic uses. Development of the reserves has been hindered by mining difficulty, high sulfur content, and variable thickness. Coal production in 1965 amounted to over one million tons, predominantly from underground mining in Gilmer County (17).

Streams Affected and Present Quality

Water quality analyses of stream waters show mine drainage to be present in the Little Kanawha River in its upper portions (Figure 8). The Little Kanawha River is intermittently polluted by mine drainage downstream to about Glenville in Gilmer County. The principal mine drainage contributors to the main stem are Copen Run, Lynch Run, Beard Run, and Duck Creek, which enter the river between the Gilmer-Braxton county line and Glenville, West Virginia. Mine drainage pollution also occurs on an intermittent basis in portions of the headwaters areas of Leading and Cedar Creeks, tributaries to the Little Kanawha in Gilmer County.

The Little Kanawha River is considered to be intermittently polluted by mine drainage from the mouth of Copen Run and extending downstream a distance of about five miles. A total of 25 miles of tributary streams are considered to be polluted by mine drainage, 20 miles on an intermittent basis.

KANAWHA RIVER

Description

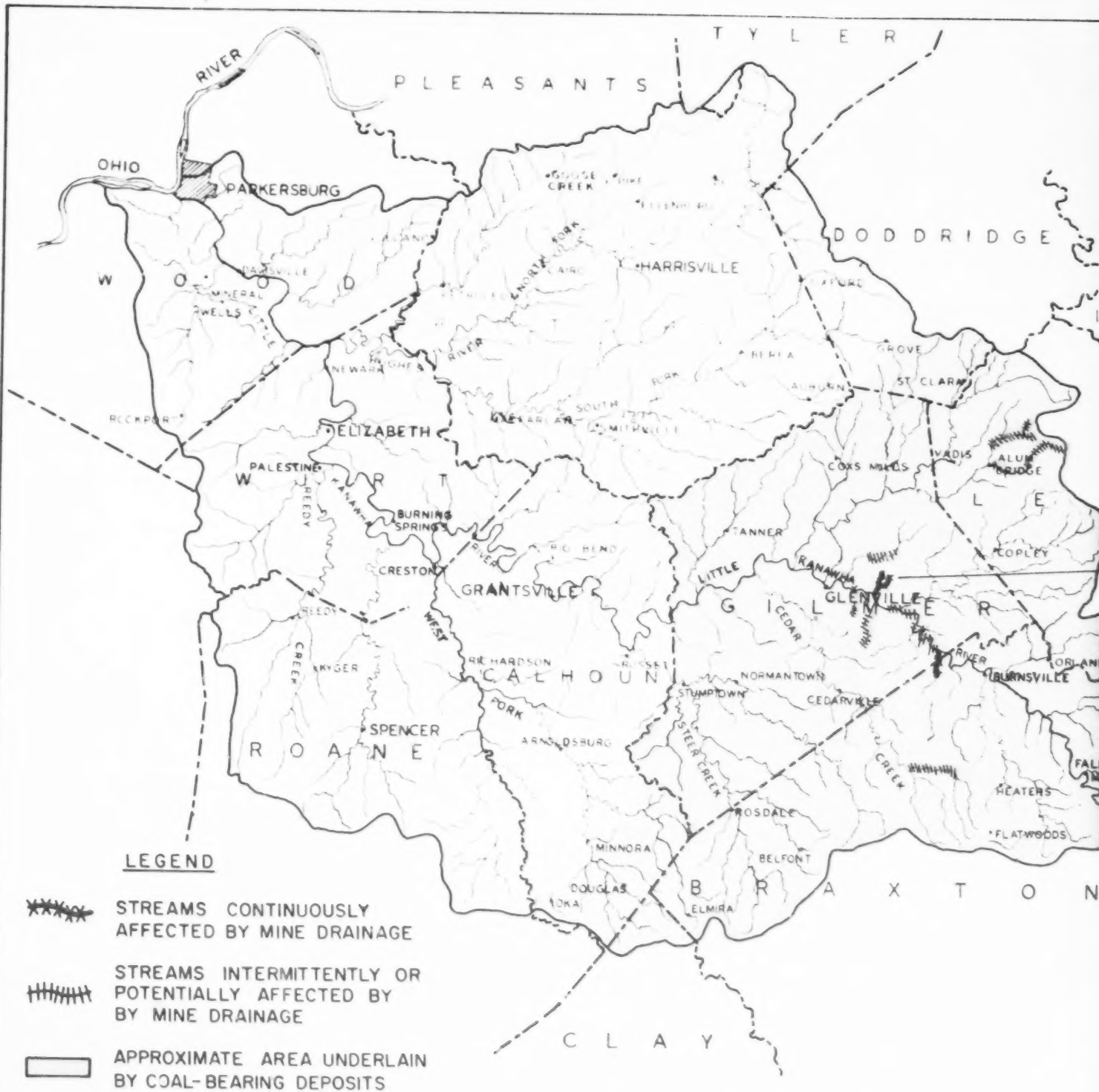
The Kanawha River basin spans the entire width of south-central West Virginia, includes the west-central portion of Virginia, and the northwestern part of North Carolina. It is bounded on the north by the Little Kanawha and Monongahela River basins, on the east by the Potomac and Roanoke River basins, on the south by the Pee Dee River basin, and on the west by the Tennessee, Big Sandy and Guyandotte River basins. The total drainage area of the Kanawha River basin is 12,300 square miles, 8,450 of which are in West Virginia, 3,080 in Virginia, and 770 in North Carolina. The Kanawha River basin is entirely within the Appalachian Region.

The Kanawha River is formed by the confluence of the New and Gauley Rivers at Gauley Bridge, West Virginia. From the point of origin it flows northwesterly for 95 miles to its junction with the Ohio River at Point Pleasant, West Virginia, 266 river miles below Pittsburgh. The main tributaries comprising the Kanawha River system are the Elk, Gauley, New and Greenbrier Rivers.

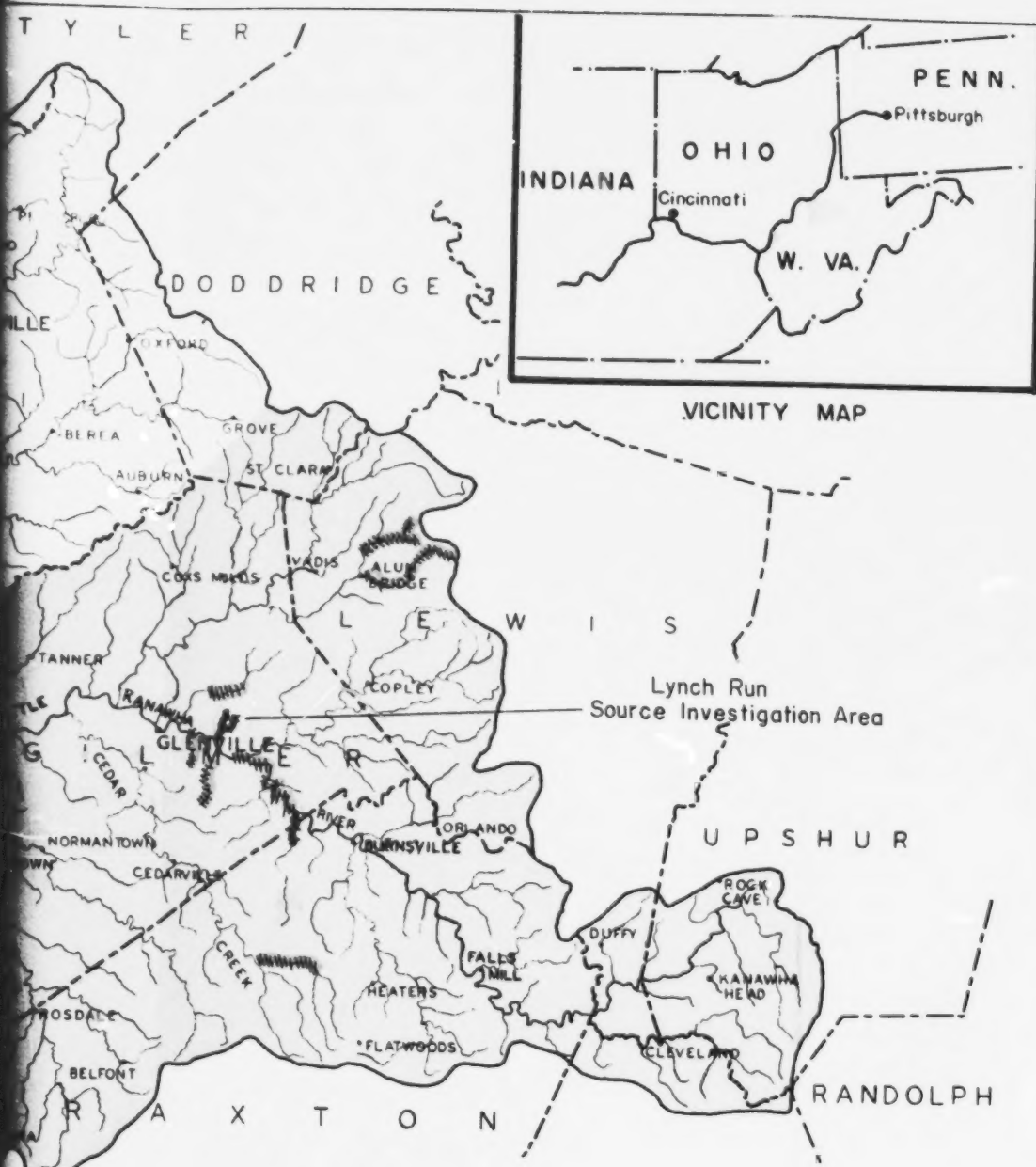
The Kanawha River basin is located in the Kanawha section of the Appalachian Plateaus physiographic province, the Tennessee section of the Valley and Ridge province, and the southern section of the Blue Ridge province. The entire basin is mountainous in character, although the upper and lower portions comprise two contrasting types of topography. Rounded hills and wide valleys characterize the Appalachian Plateaus province of the lower basin, and high mountains and deep gorges characterize the Blue Ridge province of the upper basin. The elevations of the basin range from a high of about 5,000 feet in the Blue Ridge Mountains of North Carolina to 538 feet at the mouth of the Kanawha River, giving a maximum relief of about 4,500 feet.

Agriculture, manufacturing, and mining each hold an important position in the economy of the basin. Hay is the principal agricultural product and the bulk of the rural economy is related to livestock production. Mining output continues to be important with coal the principal product extracted. However, the relative importance of manufacturing is increasing annually. Manufacturing is especially strong in the Charleston, West Virginia area. Principal communities in the basin and their 1960 populations are Charleston - 85,796; Bluefield - 19,256; South Charleston - 19,180; Beckley - 18,642; and St. Albans - 15,103. All are located in West Virginia.

A



B



APPALACHIA MINE DRAINAGE POLLUTION REPORT	
LITTLE KANAWHA RIVER BASIN 76a	
U.S. DEPARTMENT OF THE INTERIOR	
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION	WHEELING FIELD STATION
OHIO BASIN REGION	

FIGURE 8

Coal Reserves and Mining Activity

Bituminous coal deposits underlie 19 of the 21 West Virginia counties that are wholly or partly contained in the Kanawha River basin. Coal production has been reported for all but one of these 19 counties. The recoverable coal reserve in the Kanawha basin, underlying about 70 percent of the total area of the watershed, amounts to an estimated 23 billion tons. There are no coal deposits in the Virginia and North Carolina portions of the basin.

The Kanawha basin coal fields were developed very early, and have been very large producers in the history of the coal mining industry in West Virginia. Three of the counties produced more than 500 million tons of coal in the period 1883 - 1965. Coal production in the Kanawha basin in 1965 amounted to over 46 million tons. The principal producing counties were Boone, Fayette, Kanawha, and Raleigh. (17)

Streams Affected and Present Quality

Some stream pollution from mine drainage in the basin occurs in nearly all coal mining areas, but it is particularly prevalent in Kanawha, Boone, and Nicholas Counties (Figure 9). The Coal and Gauley River systems which traverse these counties contain an estimated 333 and 385 miles of mine drainage polluted streams, respectively. (Table 14)

Significant mine drainage pollution occurs in the Pocatalico, Coal, Elk, Gauley, and New River watersheds (Table 15). Generally, serious pollution conditions exist in the headwater areas of these drainages and in small tributaries to these streams. Pollution conditions in the main streams are intermittent and water quality is not severely degraded. Significant intermittent pollution also occurs in Cabin Creek and Paint Creek, tributaries to the Kanawha River in southern Kanawha County.

In the Pocatalico drainage, several small tributaries from Tupper Creek down to the Kanawha River confluence are seriously polluted by mine drainage. A survey of water quality conditions in 1964 showed that over 25 tons of acid per day were being discharged into the Pocatalico River by these tributaries.

The Coal River and its principal tributary, Little Coal River, receive mine drainage in their headwaters and many tributaries to these streams contribute mine drainage to the main stream. The

Table 14

Lengths of streams polluted by acid mine drainage-Kanawha River basin

Drainage Area	Continuously Polluted miles	Intermittently Polluted miles	Total
Kanawha River 12,240 sq. mi.		95	95
Tributaries	85	90	175
Pocatalico River	20		20
Tributaries	31	6	37
Coal River	63		63
Tributaries	104	18	122
Little Coal River	52		52
Tributaries	96		96
Elk River	20	14	34
Tributaries	60	67	127
Gauley River	87		87
Tributaries	133	165	298
New River			
Tributaries	108	89	197
	<u>859</u>	+ 544	= 1403

Coal and Little Coal Rivers are intermittently polluted by mine drainage over their lengths. Sulfate concentrations of 250 mg/l are frequently exceeded in the Coal River watershed due to mine drainage.

The Elk River, water supply source for Charleston, West Virginia intermittently receives mine drainage from the Birch River in northern Nicholas County, Buffalo Creek in Clay County, and Blue Creek in Kanawha County. Mine drainage also occurs in the Elk River from mining areas in the Webster Springs area, Webster County.

The Gauley River receives intermittent mine drainage at various locations along its length and from the Cherry River, Beaver Creek, Brushy Fork, Hominy Creek, and Twentymile Creek. Although the intensity of pollution in the Gauley River watershed is not great, this drainage area contains more miles of affected streams than the other tributary basins to the Kanawha River.

In the New River basin, the Bluestone River in Summers and Mercer counties and Piney and Coal Creeks in the Beckley, W. Va. area are intermittently affected by mine drainage. A number of smaller tributaries to the New River are also affected. The principal tributary to the New River, the Greenbrier River, is totally unaffected by mine drainage.

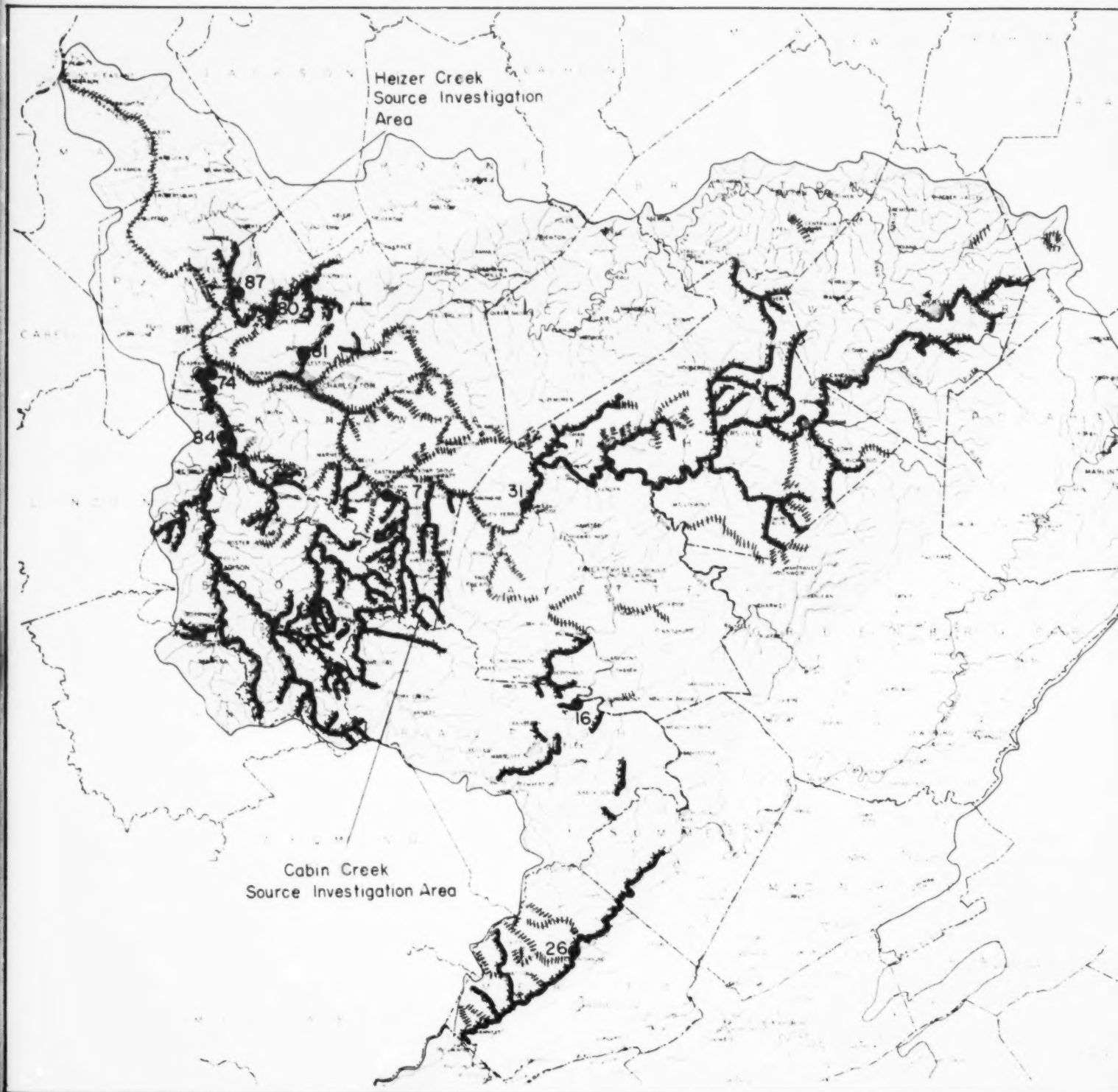
Water quality data gathered by the Wheeling Field Station in 1964 reveals that concentrations of iron exceed 0.3 mg/l in the watersheds of all principal tributaries to the Kanawha River.

In many parts of the Kanawha basin coal mine discharges are alkaline rather than acid. A number of small communities utilize abandoned mines and mine discharges as sources of domestic supply. In West Virginia, eight million gallons of mine water per day were used for public water supply in 1960. (22).

Table 15 - Water Quality Data, Kanawha River basin

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
26	Min. Max. Avg.	7.9 9.6 8.6	0.0 1.0 0.1	97.0 180.0 131.4	158.0 182.0 166.0		0.0 0.8 0.4			13.5 66.0 41.2
16	Min. Max. Avg.	7.7 9.0 8.4	0.0 2.0 0.4	37.0 80.0 59.5	56.0 152.0 117.8		0.2 0.6 0.4			5.3 29.5 13.8
31	Min. Max. Avg.	6.7 9.8 8.6	0.0 0.0 0.0	55.0 83.0 59.6	62.0 68.0 66.0		0.0 0.4 0.2			1100.0 4300.0 2762.5
7	Min. Max. Avg.	4.9 6.6 5.5	6.0 105.0 56.6	1.0 99.0 13.3	532.0 564.0 551.5		0.1 900.0 57.3			1.2 15.4 7.3
81	Max.	5.7	116.0	10.0			0.2			0.1
84	Max.	7.7	0.0	43.0			0.2			40.0
74	Max.	7.9	0.0	48.0	202.0		0.4			67.0
87	Min. Max. Avg.	7.8 8.5 8.1	0.0 0.0 0.0	75.0 99.0 86.0	136.0 248.0 176.6		0.5 1.2 0.9			0.5 1.5 0.8
80	Min. Max. Avg.	3.8 950.0	0.0		1440.0	3590.0	75.0			0.4

A



B



VICINITY MAP

LEGEND

-  STREAMS CONTINUOUSLY AFFECTED BY MINE DRAINAGE
-  STREAMS INTERMITTENTLY OR POTENTIALLY AFFECTED BY MINE DRAINAGE
-  APPROXIMATE AREA UNDERLAIN BY COAL-BEARING DEPOSITS
-  108 SAMPLING STATION

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**APPALACHIA MINE DRAINAGE POLLUTION
REPORT**

KANAWHA RIVER BASIN

80a

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION WHEELING FIELD STATION

SCIOTO RIVER

Description

The Scioto River basin lies in the central portion of Ohio, its eastern limits nearly coinciding with the north-south center line of the State, and forms the principal drainage system of central and southern Ohio (Figure 10). The Scioto River rises in northwestern Ohio, flows east 60 miles where it is joined by the Little Scioto, then south 175 miles where it enters the Ohio River at Portsmouth, Ohio, 356 river miles below Pittsburgh, Pennsylvania. The total drainage area of the basin is 6,510 square miles, comprising about 16 percent of the land area of the State and covering part or all of 31 counties. The Scioto basin is roughly rectangular in shape, about 135 miles long and 50 to 60 miles wide except for the lower 30 miles where it narrows to about 25 miles. The basin extends north beyond Marion, east beyond Galion and Jackson, and west beyond Kenton, London, and Hillsboro. Principal tributaries to the Scioto include the Olentangy River and Big Walnut, Big Darby, Deer, Paint, and Salt Creeks. The principal communities in the basin and their 1960 populations are Columbus - 471,316; Marion - 37,079; Upper Arlington - 28,486; Chillicothe - 24,957; and Whitehall - 20,818.

The portions of eight counties that make up the lower Scioto basin, about one-third of the watershed, are contained in the Appalachian Region.

Agricultural and diversified industrial production are the economic mainstays of the basin. There is no significant coal production in the Scioto basin since only the fringe of the southern Ohio coal fields is within the watershed in its southeastern corner. Reported coal production is limited to Jackson, Vinton, and Hocking Counties.

A small recoverable coal reserve of about 150 million tons is estimated for the Scioto basin. The Vinton and Jackson County portions of the watershed contain most of the reserve. (19) (20).

Streams Affected and Present Quality

Significant stream pollution by coal mine drainage in the Scioto basin is limited to Pike Run and another small tributary to Salt Creek in Vinton County, amounting to about eight miles of streams which are intermittently polluted by mine drainage (Figure 10).

Because of the very small area of the basin underlain by coal, stream pollution by mine drainage will not become a problem except on a very localized scale.

GUYANDOTTE RIVER

Description

The Guyandotte River drains 1,670 square miles of southwestern West Virginia, about seven percent of the state (Figure 11). It is bounded on the west by the Big Sandy River basin and on the east by the Kanawha River basin. The Guyandotte River has its source near Rhodell, West Virginia, in southern Raleigh County at the confluence of Winding Gulf and Stone Coal Creeks. It flows in a westerly direction for approximately 50 miles to the town of Gilbert, where it turns north and continues for 115 miles to discharge into the Ohio River at Huntington, 305 miles below Pittsburgh, Pennsylvania. The only major tributary is the Mud River, which drains 358 square miles and enters the Guyandotte at Barboursville, seven miles above its mouth. Many small upper basin tributaries drain the important coal mining areas in Logan and Wyoming Counties and part of Raleigh County. Eight counties lie wholly or partly in the basin. All of the Guyandotte River basin is contained in the Appalachian Region.

The topography of the basin is mountainous and consists of a maze of hills and valleys. Altitudes range from under 1,000 feet to between 2,000 and 3,000 feet in the middle and upper portions of the basin. The gradient of the upper half of the river is 11 feet per mile, but in the lower 71 miles the gradient is only 1.8 feet per mile. The Mud River follows the wide valley of the ancient Teays River for much of its length.

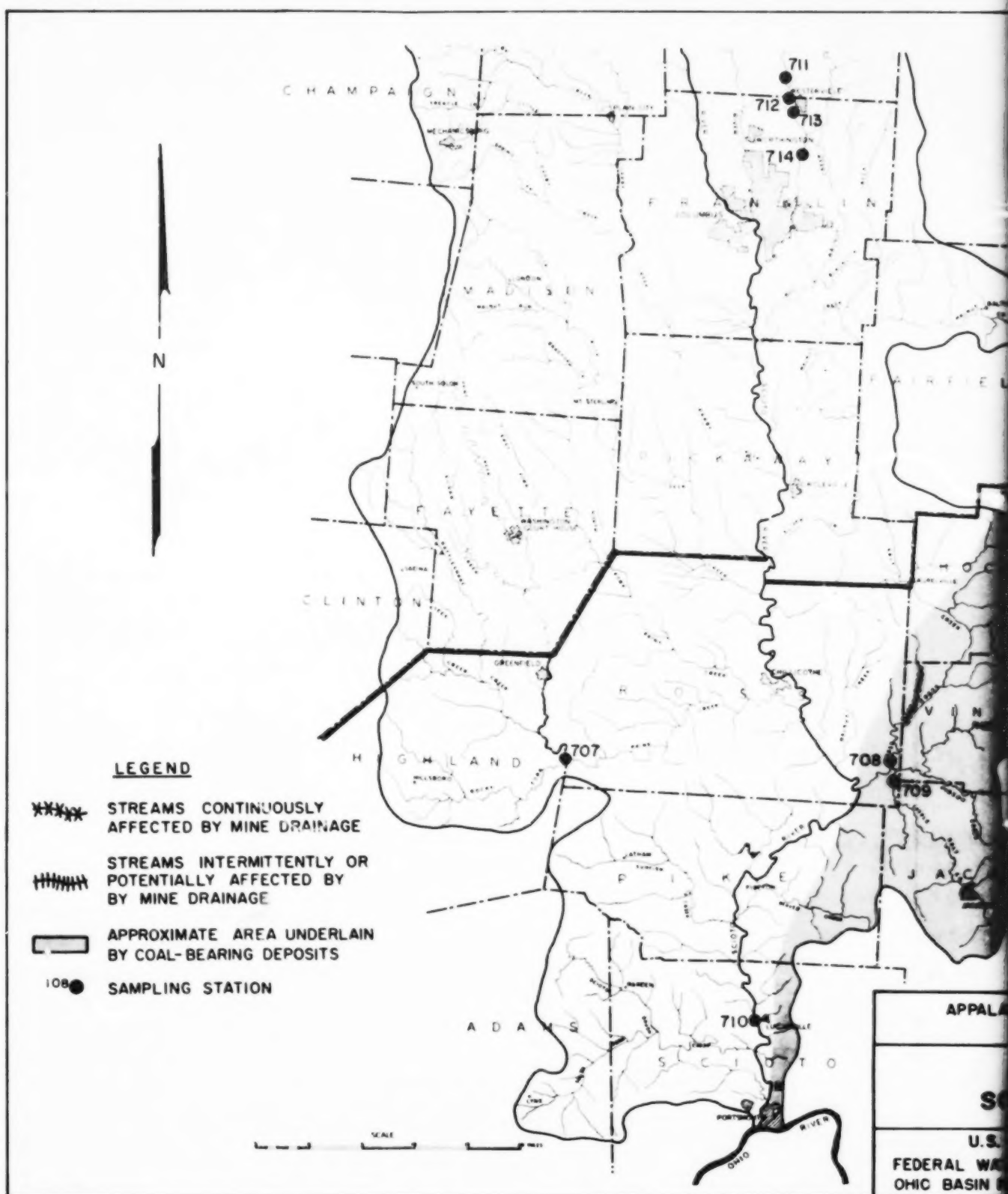
There is a small agricultural contribution to the economy, although the terrain is too steep to permit farming on a large scale. Coal mining has been the mainstay of the economy, and many of the small industries in the area are support industries for mining. The major communities in the basin and their 1960 populations are Logan - 4,185; Mullens - 3,544; and, Mount Gay - 3,386.

Coal Reserves and Mining Activity

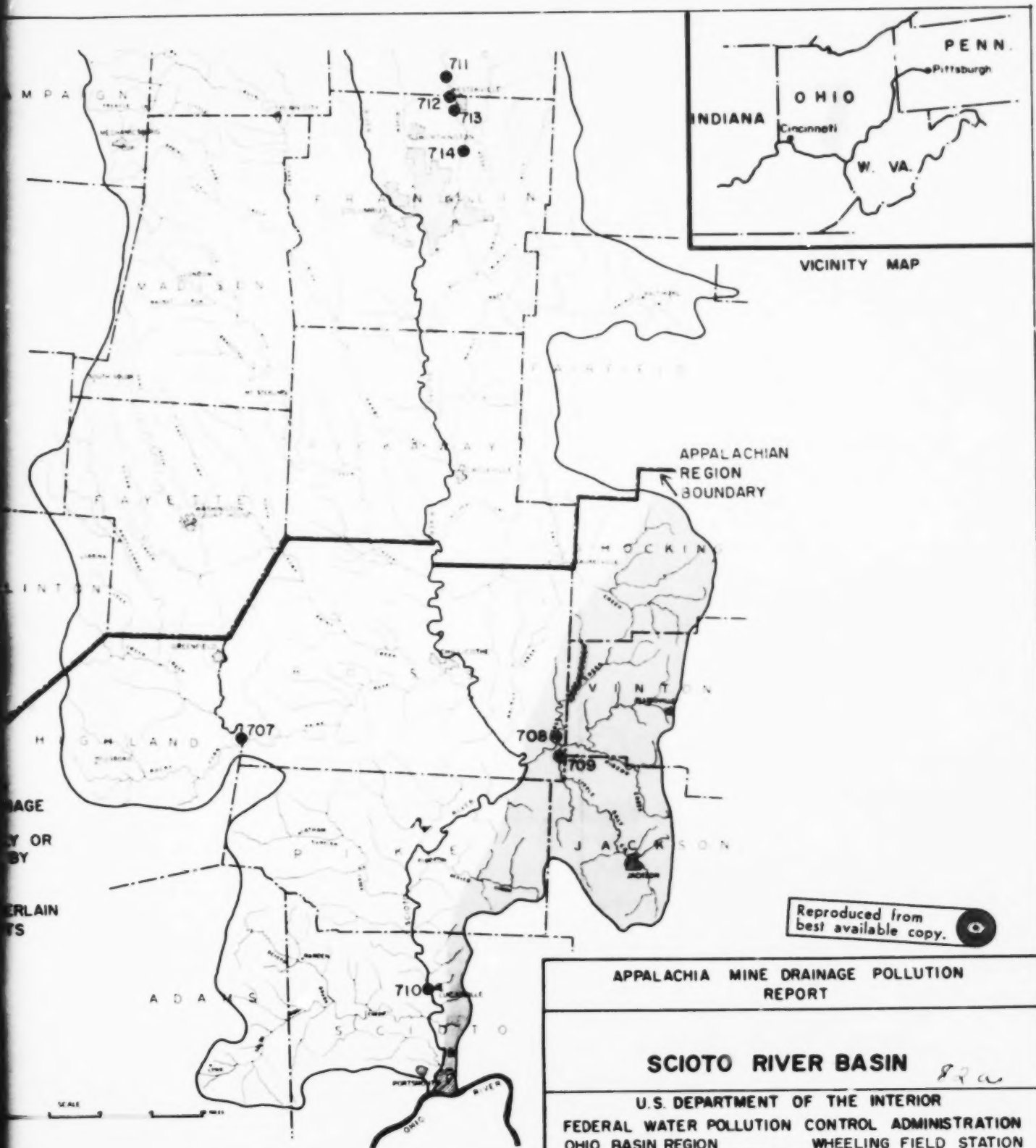
Recoverable coal reserves underlie almost all of the drainage area. Only portions of Mingo and Cabell Counties are devoid of mineable coal reserves. The recoverable coal reserve of the Guyandotte River basin is estimated at about five billion tons. The production of coal has been the dominant industry in this area for a long time and should continue to be in view of the remaining coal reserve.

Over the period of record, 1883-1965, more than two billion tons of coal were produced from the eight counties comprising the basin. More than 30 million tons were produced in the basin in 1965. The principal producing counties were Logan, Wyoming, Lincoln and Raleigh (17). Logan County has the largest cumulative production figure, 885 million tons. Cabell County has no recorded coal production.

A



B



APPALACHIA MINE DRAINAGE POLLUTION
REPORT

SCIOTO RIVER BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION WHEELING FIELD STATION

FIGURE 10

Streams Affected and Present Quality

Because coal mining is the major industry in the upper half of the watershed, many streams there are affected by this activity (Figure 11, Table 17). Serious water quality problems are commonly caused by silt and fine coal particles emanating from coal mining and coal preparation sites. The Raleigh and Wyoming County portions of the basin are particularly affected in terms of numbers of streams and total miles of streams degraded.

Table 16 shows the miles of streams considered by this survey to be polluted by coal mine drainage.

Table 16

Lengths of streams polluted by mine drainage, Guyandotte River basin

Stream	Drainage Area (Sq. Mi.)	Continuously Polluted (Miles)	Inter-mittently Polluted (miles)	Total miles
Guyandotte River	1,680	164		164
Tributaries to Guyandotte		124	11	135
		288	+ 11	= 299

The Guyandotte receives mine drainage in its upper portion from Stonecoal Creek, Devils Fork, Allen Creek, Slab Fork, and Barkers Creek (Sta. 178). The Guyandotte River at Tralee, West Virginia (Sta. 190) below the affected tributaries mentioned, contained acidity in excess of alkalinity on one occasion during the stream survey. The stream pH did not fall under 6.8 but total mineralization, hardness, sulfate, iron, and manganese were high as a result of the upstream mine drainage influence.

Downstream from Tralee (Sta. 190) the Guyandotte River receives small amounts of mine drainage from tributaries in Wyoming County above Clear Fork, principally Pinnacle and Indian Creeks.

Clear Fork was the largest contributor of acid to the Guyandotte River during the 1966 survey. Virtually the entire Clear Fork watershed is polluted. Laurel Fork of Clear Fork near Jesse, West Virginia

(Sta. 179) carried an average net acid load of 12 tons per day and had a minimum pH of 5.4. Clear Fork at Toney Fork, West Virginia (Sta. 180) had a pH range of 3.5 to 5.7 and carried a net acidity load of 37 tons per day.

Little Huff Creek, which enters the main stream at the Wyoming County line (Sta. 184), discharged an average acid load of 4.6 tons per day during the study period.

Little additional mine drainage enters the Guyandotte in the Logan County reach of the stream. Island Creek is the principal affected stream in this section. Island Creek (Sta. 187) was an alkaline stream when studied but had high concentrations of hardness, sulfate, iron, and manganese (Table 17).

The Guyandotte River near Logan, West Virginia (Sta. 198) was an alkaline stream and had assimilated the acid loads received over the Wyoming County reach of the drainage area. Residual effects of mine drainage were reflected at this location in high concentrations of other related constituents (Table 17).

The Guyandotte River at Branchland, West Virginia (Sta. 189) is generally an alkaline stream but as at Logan, it had high hardness, sulfate, and metal concentrations. Near its mouth (Sta. 197) the Guyandotte was alkaline and carried high concentrations of mine drainage-related constituents (Table 17).

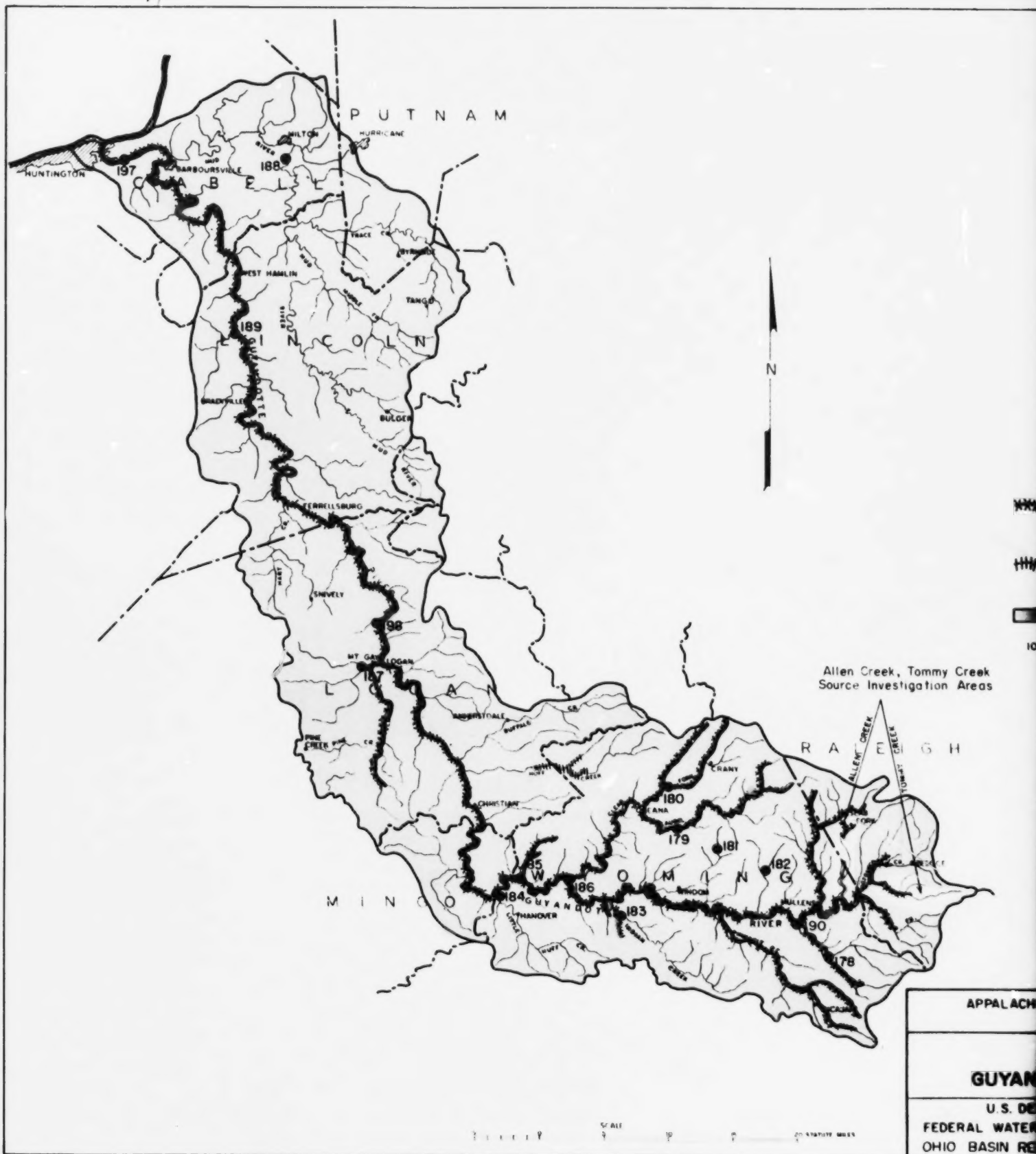
One of the major water quality problems in the Guyandotte basin is the intermittent occurrence of fine coal and silt in the streams. These materials are washed from mining areas during periods of precipitation or are allowed to escape from mining and preparation facilities.

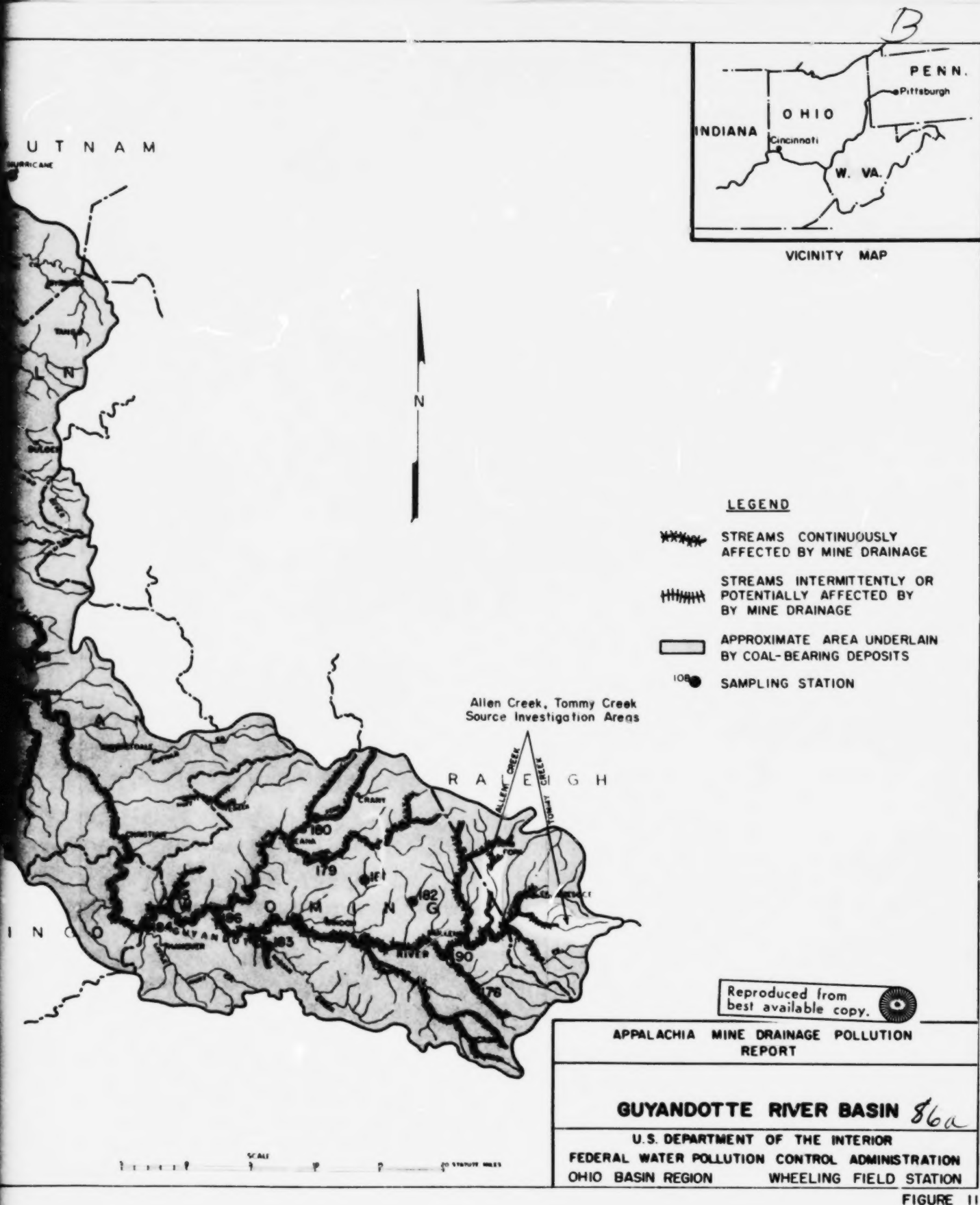
Table 17 - Water Quality Data, Guyandotte River basin

Map Station No.	No. of Samples	Min.	Max.	Avg.	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
178	6	6.7	7.7	6.9	0.0	12.0	23.0	35.0	0.0	0.0	0.0	0.8	0.4
					61.0	119.0	110.0	66.0	8.4	8.4	2.1	8.5	76.5
					17.0	34.0	55.5	46.5	1.8	1.8	0.6	2.5	18.0
179	6	5.4	7.1	6.6	5.0	2.0	45.0	40.0	0.6	0.6	0.5	1.1	2.0
					115.0	54.0	109.0	130.0	12.0	12.0	2.4	5.0	500.0
					38.0	26.7	73.8	81.2	3.2	3.2	0.9	2.6	145.2
180	6	3.5	5.7	4.4	58.0	0.0	162.0	165.0	0.0	0.0	2.0	7.5	0.6
					608.0	13.0	340.0	690.0	216.0	216.0	58.6	260.0	180.0
					274.8	3.8	251.2(5)*	348.3	42.4	42.4	13.7	59.7	63.9
181	6	3.8	6.5	6.0	5.0	0.0	14.0	20.0	0.2	0.2	0.0	0.3	0.4
					25.0	17.0	70.0	23.0	0.6	0.6	0.3	0.6	12.0
					16.3	9.8	32.5	20.8	0.4	0.4	0.2	0.5	3.2
182	4	6.1	7.3	6.5	3.0	10.0	15.0	14.0	0.6	0.6	0.2	0.7	1.0
					24.0	18.0	58.0	23.0	4.2	4.2	0.8	5.9	28.9
					12.5	13.3	33.3	19.3	1.9	1.9	0.4	2.8	10.9
183	6	6.7	7.2	6.9	0.0	8.0	24.0	3.0	0.5	0.5	0.1	0.6	0.4
					115.0	74.0	57.0	25.0	1.2	1.2	0.4	4.2	220.0
					31.2	40.8	40.5	15.3	0.8	0.8	0.2	2.0	61.3
184	6	6.4	7.1	6.8	12.0	8.0	15.0	30.0	0.6	0.6	0.2	0.0	1.0
					79.0	150.0	115.0	75.0	18.7	18.7	3.1	18.7	420.0
					40.3	41.2	66.7	55.7	5.1	5.1	0.9	5.1	94.4
185	6	6.8	7.6	7.2	0.0	18.0	74.0	75.0	0.0	0.0	0.2	0.0	65.0
					39.0	196.0	162.0	238.0	6.2	6.2	3.4	4.0	4120.0
					15.7	86.0	101.2	121.3	2.5	2.5	1.0	1.5	986.2

Map Station No.	No. of Samples	pH	Acidity (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	Sulfate (mg/L)	Total Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Flow (cfs)
186	6	5.1 5.5 5.7	7.0 316.0 82.0	1.0 15.0 5.8	26.0 297.0 148.2	65.0 425.0 216.7	0.0 94.0 17.6	0.7 14.0 4.4	1.8 19.0 6.1	1.0 460.0 131.0
187	6	6.7 7.6 7.2	0.0 28.0 12.2	90.0 334.0 250.3	135.0 300.0 214.2	225.0 625.0 445.8	3.1 8.8 5.6	0.3 0.7 0.5	0.0 8.1 3.3	20.0 80.0 36.4
188	6	6.4 8.0 7.1	0.0 20.0 9.3	7.0 48.0 36.8	35.0 82.0 56.5	2.0 30.0 17.5	0.1 5.9 1.8(5)	0.0 3.4 1.2	0.1 2.1 1.1(5)	1.0 975.0 183.0
189	6	6.7 7.3 7.0	0.0 27.0 7.0	22.0 121.0 78.5	95.0 248.0 166.5	90.0 400.0 212.5	0.3 8.4 2.4	0.0 0.7 0.4	1.9 6.2 3.1	83.0 2855.0 661.0
190	6	6.8 7.9 7.4	0.0 28.0 9.5	26.0 199.0 136.5	73.0 170.0 125.2	53.0 260.0 179.7	1.1 3.4 1.9	0.1 1.6 0.7	1.1 3.6 2.3	26.5 900.0 200.3
197	6	6.6 7.5 7.1	0.0 28.0 8.7	38.0 100.0 67.7	100.0 190.0 141.0	110.0 340.0 195.8	0.2 4.9 2.5	0.1 1.1 0.5	0.4 4.7 3.2	140.0 6000.0 1346.7
198	6	6.9 7.4 7.1	0.0 26.0 9.8	22.0 155.0 86.0	70.0 230.0 160.3	85.0 345.0 210.8	0.4 3.8 1.7	0.1 0.8 0.4	0.9 8.2 4.2	65.0 250.0 105.0

*(5) Indicates the number of samples used in averages when other than the maximum.





BIG SANDY RIVER

Description

The Big Sandy River is formed by the junction of Tug and Levisa Forks at Louisa, Kentucky, and flows northerly 27 miles to enter the Ohio River about 10 miles downstream from Huntington, West Virginia. It drains 4,280 square miles, of which 2,330 are drained by Levisa Fork and 1,550 by Tug Fork (Figure 12). Levisa Fork rises in southwestern Virginia and flows north for 34 miles in Virginia and 130 miles in Kentucky to Louisa. Tug Fork rises in southwestern West Virginia and flows northwest about 60 miles to Kentucky, where it forms the boundary with West Virginia for about 94 miles. Principal tributaries to Levisa Fork of the Big Sandy River are Russell Fork, Beaver Creek, and Johns Creek. The basin is bounded by the Guyandotte River basin on the east, the Tennessee River basin on the south and the Kentucky and Licking River basins on the west. All of the Big Sandy River basin is within the Appalachian Region.

The basin varies from mountainous terrain in its upper portions to hilly areas along the Big Sandy River. Some of the most rugged portions of the three states is found in the headwaters of the Tug and Levisa Forks of the Big Sandy River.

Principal economic activities in the basin are the mining, processing, and transporting of coal, farming, gas and oil production, and lumbering. The principal communities in the basin and their 1960 populations are Williamson, West Virginia - 6,746; Welch, West Virginia - 5,313; Pikeville, Kentucky - 4,754; and Paintsville, Kentucky - 4,025.

Coal Reserves and Mining Activity

Coal production is the major industry in the basin and there are more than 2,800 active mines, the majority of which are underground. Bituminous coal reserves are present in 16 of the counties that are either wholly or partly within the basin. In 1963 the total recoverable coal reserves were estimated to be more than 11 billion tons. Coal has been mined in most of the counties, and in 1965 production was more than 65 million tons. The major producing counties were Pike and Floyd Counties in Kentucky; Buchanan, Dickinson, and Wise Counties in Virginia; and McDowell and Mingo Counties in West Virginia. (17) (23) (24) (25)

Streams Affected and Present Quality

Because coal mining is a major industry in the upstream reaches of the basin, many streams are affected by the activity (Figure 12, Table 19). Serious water quality problems are caused by the fine coal and silt discharged or spilled from coal washeries.

Approximately 500 miles of streams were found by this study to be polluted by coal mine drainage and other mining activities. (Table 18)

Table 18

Lengths of streams polluted by mine drainage.

Big Sandy River basin				
STREAM	DRAINAGE AREA Square Miles	CONTINUOUSLY POLLUTED (Miles)	INTERMITTENTLY POLLUTED (Miles)	TOTAL (Miles)
Big Sandy River	4,294		27	27
Tributaries to Big Sandy			2	2
Tug Fork	1,550		70	70
Tributaries to Tug Fork		58	74	132
Levisa Fork	2,330		131	131
Tributaries to Levisa Fork			138	138
		58	+	442
			-	500

Tributary streams of the basin in which mine drainage pollution effects have been observed to be the most serious are those in the headwaters in McDowell and Mingo Counties, West Virginia; Buchanan and Dickinson Counties, Virginia; and Pike and Floyd Counties, Kentucky. The streams in these locations drain the areas of heaviest mining activity in the basin.

Generally, the streams in the Big Sandy River basin that are affected by mine drainage, although highly mineralized, are not characterized by high acidity concentrations. Fine coal and silt are often present in the streams of the basin due to surface runoff and discharges from coal mining and preparation sites. Concern has been expressed over detrimental effects of coal washery discharges above Fishtrap Reservoir on Levisa Fork near the Kentucky-Virginia line.

Tug Fork of Big Sandy River receives some intermittent mine drainage directly in its reach above Welch, West Virginia and from the Elkhorn Creek, Dry Fork, and Panther Creek watersheds (Sta. 192) in McDowell County, West Virginia. Tug Fork near Iaeger, West Virginia (Sta. 194) reflected the mine drainage influence in total mineralization, and high sulfate, iron, and manganese concentrations (Table 19).

In the Mingo County, West Virginia reach of the Tug Fork several small tributaries contribute mine drainage to the main stream above Williamson, West Virginia. Below Williamson, Pigeon Creek in West Virginia and Big Creek and Wolf Creek in Kentucky are affected. Pigeon Creek (Sta. 196), had a minimum pH of 6.4 and a maximum conductivity of 1,300 micromhos per centimeter during the survey. It contained high hardness, sulfate, iron, and manganese concentrations on occasion and had acidity in excess of alkalinity on one occasion.

Tug Fork below Pigeon Creek, near Kermit, West Virginia, (Sta. 195) had a minimum pH of 5.9, acidity in excess of alkalinity on one occasion, and high concentrations of sulfate, iron, and manganese during part of the study period.

Like Tug Fork, Levisa Fork is affected in its headwaters area. Levisa Fork at the Kentucky-Virginia State line (Sta. 02) discharged an average acid load of 15 tons per day. The pH did not go below 6.7, but the water contained high concentrations of mine drainage-related constituents (Table 19).

Russell Fork (Sta. 03) contributed an average net acid load of 20 tons per day to Levisa Fork. The pH of this stream did not fall below 6.2.

Levisa Fork below Pikeville (Sta. 09) contained high residual concentrations of sulfate, iron, and manganese from mine drainage received in its upper reaches (Table 19).

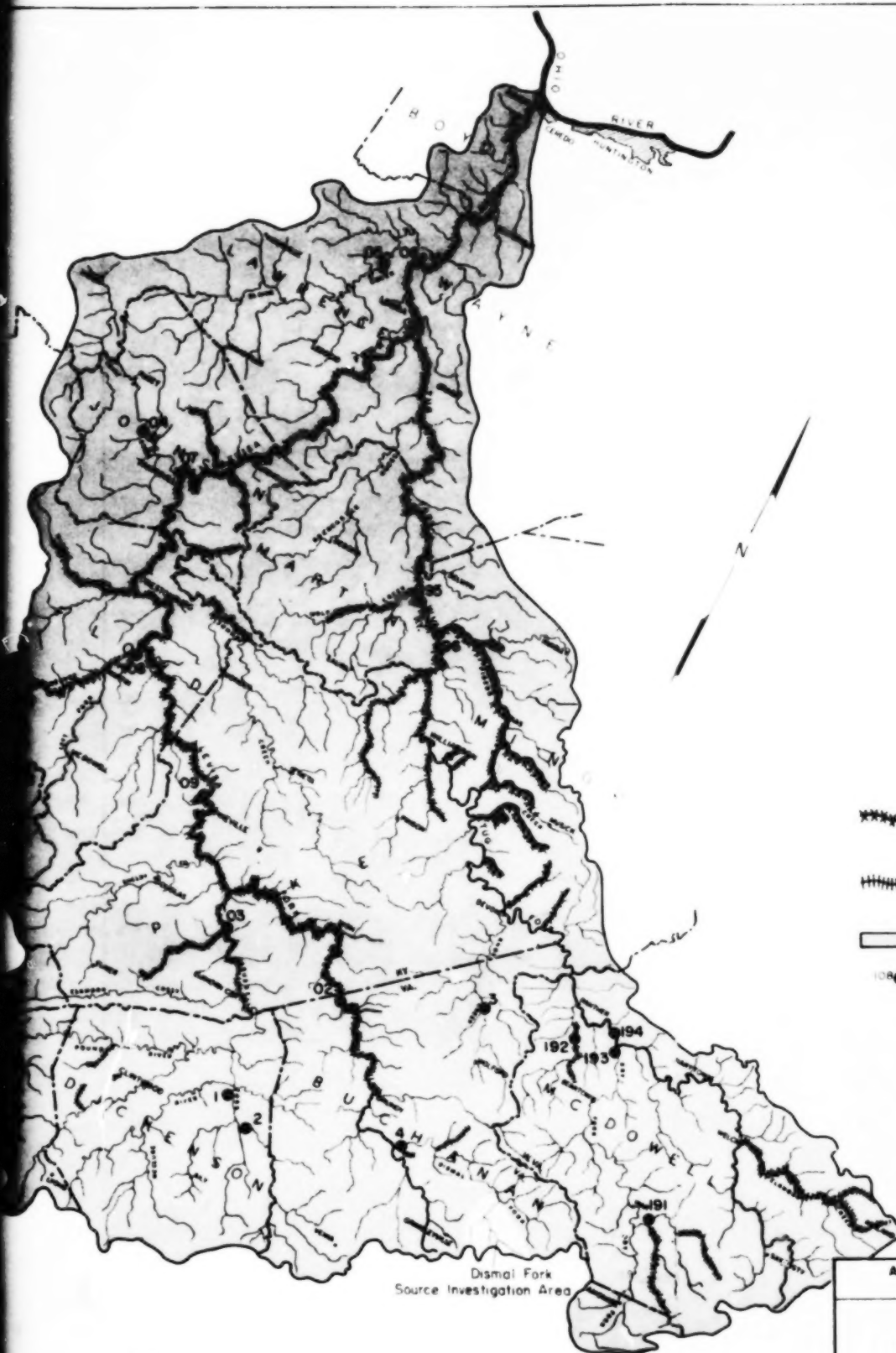
Below Pikeville there are several tributaries to Levisa Fork that intermittently contribute additional quantities of mine drainage in Floyd and Johnson Counties, Kentucky. Beaver, Middle Johns, Toms, and Greasy Creeks in these counties are intermittently polluted by mine drainage.

The Big Sandy River at Louisa, Kentucky (Sta. 06) contained acidity in excess of alkalinity during part of the survey. However, the stream carried an average net acid load of 8.9 tons per day for the entire survey period. Sulfate, iron, manganese and hardness concentrations were 52-320 mg/l, 1.0-25.0 mg/l, 0.1 to 1.3 mg/l, and 60 to 582 mg/l, respectively.

Table 19 - Water quality data, Big Sandy River basin

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
	Min.	6.7	0.0	13.0	103.0	80.0	0.6	0.3	1.4	6.7
	Max.	7.8	28.0	56.0	348.0	400.0	9.1	1.6	9.9	4300.0
	Avg.	7.2	14.0	32.8	251.7	233.3	3.1	0.8	4.0	759.3
03	Min.	6.2	0.0	20.0	18.0	40.0	0.5	0.7	1.3	27.3
	Max.	7.9	175.0	55.0	124.0	100.0	115.0	12.4	107.0	3470.0
	Avg.	7.2	39.7	36.2	69.0	70.0	22.3	3.1	21.1	1533.1
04	Min.	6.7	0.0	35.0	144.0	15.0	0.0	0.2	0.0	2.0
	Max.	7.8	96.0	66.0	656.0	50.0	16.8	1.3	63.8	61.0
	Avg.	6.9	21.0	48.7	336.2	29.2	3.3	0.5	11.2	25.7
05	Min.	6.4	13.0	15.0	190.0	12.0	0.0	0.1	0.6	11.0
	Max.	7.0	63.0	38.0	920.0	30.0	12.0	2.5	25.2	320.0
	Avg.	6.7	30.7	24.5	455.0	23.2	3.1	1.1	7.3	92.6
06	Min.	6.9	2.0	19.0	60.0	52.0	1.0	0.1	1.2	170.0
	Max.	7.4	92.0	86.0	582.0	320.0	25.0	1.3	19.1	1680.0
	Avg.	7.1	28.3	49.3	190.3	139.5	7.0	0.7	6.1	889.2
07	Min.	6.2	0.0	25.0	58.0	45.0	0.0	0.3	0.0	105.0
	Max.	7.4	43.0	48.0	140.0	110.0	15.6	4.6	24.0	11000.0
	Avg.	6.8	18.8	33.2	93.0	79.5	6.0	1.4	7.8	3980.5
08	Min.	7.2	0.0	28.0	54.0	85.0	1.0	0.3	0.4	8.1
	Max.	7.6	24.0	111.0	186.0	185.0	5.0	1.5	3.4	690.0
	Avg.	7.3	13.8	74.0	142.2	135.8	2.8	0.8	1.9	225.6
09	Min.	6.7	0.0	29.0	60.0	40.0	1.2	0.5	2.1	190.0
	Max.	7.7	35.0	65.0	152.0	155.0	10.3	2.9	9.8	6900.0
	Avg.	7.1	20.5	41.3	105.0	96.3	6.3	1.6	6.4	2341.7

Map Station No.	No. of Samples	pH	Acidity (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	Sulfate (mg/L)	Total Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Flow (cfs)
1	Min. Max. Avg.	6.9 7.8 7.4	0.0 25.0 10.3	46.0 125.0 80.7	50.0 130.0 80.7	36.0 195.0 86.7	0.4 3.4 1.2	0.0 2.4 0.8	0.3 2.5 1.2	0.5 228.0 57.4
2	Min. Max. Avg.	7.4 8.4 8.0	0.0 25.0 6.5	56.0 167.0 93.5	25.0 128.0 77.5	40.0 245.0 105.2	0.1 1.6 0.6	0.0 1.3 0.4	0.4 3.0 1.4	0.4 98.2 29.8
3	Min. Max. Avg.	5.8 7.2 6.7	0.0 48.0 18.7	10.0 87.0 46.3	15.0 255.0 146.0	35.0 270.0 139.8	0.5 16.8 3.6	0.2 2.9 0.8	0.7 22.5 4.8	0.3 1400.0 265.2
4	Min. Max. Avg.	5.5 7.9 6.8	5.0 59.0 26.8	2.0 27.0 17.5	107.0 350.0 249.8	80.0 415.0 240.8	0.4 9.1 2.8	0.7 1.8 1.3	0.0 9.4 3.2	1.7 360.0 73.7
191	Min. Max. Avg.	6.6 7.2 6.9	5.0 50.0 25.7	9.0 60.0 33.0	37.0 273.0 139.2	40.0 300.0 138.8	0.3 21.6 4.5	0.2 3.3 1.2	0.1 17.2 4.3	0.2 1100.0 193.7
192	Min. Max. Avg.	6.6 7.3 7.1	4.0 46.0 25.7	12.0 46.0 29.0	13.0 67.0 46.2	25.0 86.0 51.5	0.3 6.0 2.3	0.2 1.1 0.6	0.4 4.0 1.8	1.0 1630.0 292.8
193	Min. Max. Avg.	6.4 8.6 7.7	0.0 31.0 8.0	47.0 326.0 194.2	38.0 110.0 87.7	45.0 130.0 80.8	0.0 13.4 3.2	0.1 2.9 0.7	0.0 17.5 4.8	18.6 880.0 230.1
194	Min. Max. Avg.	6.8 8.1 7.7	0.0 57.0 20.2	52.0 299.0 193.3	67.0 188.0 118.8	50.0 220.0 133.2	0.0 14.3 3.9	0.1 2.8 0.8	0.0 14.9 6.0	63.0 2879.0 784.3



LEGEND

- STREAMS CONTINUOUSLY AFFECTED BY MINE DRAINAGE
- STREAMS INTERMITTENTLY OR POTENTIALLY AFFECTED BY MINE DRAINAGE
- APPROXIMATE AREA UNDERLAIN BY COAL-BEARING DEPOSITS
- SAMPLING STATION

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APPALACHIA MINE DRAINAGE POLLUTION
REPORT

BIG SANDY RIVER BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

FIGURE 12

OHIO RIVER MAIN STEM AND MINOR TRIBUTARIES

Description

Areas along both banks of the Ohio River main stem from Pittsburgh, Pennsylvania to Meldahl Dam on the Ohio near Foster, Kentucky, draining directly to the river, are included in this section of the study (Figure 13, 14, and 15). The sum of the minor tributary drainage areas along this 438 mile stretch of the Ohio River is about 14,000 square miles. The largest of the tributaries in this area so defined are Little Beaver Creek (Ohio-Pennsylvania); Middle Island Creek (West Virginia); Raccoon Creek (Ohio); Twelvepole Creek (West Virginia); Little Muskingum River (Ohio); and, Ohio Brush Creek (Ohio).

In Pennsylvania, the Ohio River flows within the unglaciated part of the Appalachian Plateau. Chartiers and Raccoon Creeks, the major tributaries entering from the south in Pennsylvania, drain a hilly, unglaciated section of the plateau. Between the Pennsylvania border and Wheeling, West Virginia the river continues to flow through an area unmodified by glacial action, so the topography remains rather rugged and dissected. It is drained by many short streams entrenched in fairly deep, narrow valleys.

The valley of the Ohio River gradually widens downstream. At Point Pleasant, West Virginia, the valley contains alluvial deposits about two and one-half miles wide and in some places these deposits are more than 100 feet thick. The Ohio Valley is bordered by an almost continuous band of rough unglaciated land from the mountainous headwater regions of western Pennsylvania through the hilly country of southeastern Ohio into the Knobs section of Kentucky. The minor tributary drainage areas are generally hilly and rough.

The Pennsylvania section of the main stem drainage area is heavily industrialized with major manufacturing categories being primary metals, fabricated metals including structural steel, electrical and nonelectrical machinery, food processing, and other durable goods. Primary metals, chemicals, and other durables are major employment categories in the upper Ohio and Huntington reaches of the river. The principal communities in this drainage area and their 1960 populations are Pittsburgh, Pennsylvania - 604,332; Huntington, West Virginia - 83,627; Wheeling, West Virginia - 53,400; and, Parkersburg, West Virginia - 44,797. These four cities are located directly on the Ohio River.

With the exception of Columbiana and Mahoning Counties (Ohio) in the Pittsburgh to New Cumberland Dam reach of the Ohio River, and Bracken and Mason Counties, Kentucky, in the Belleville to Meldahl

Dam reach, the entire drainage area is contained in the Appalachian Region.

Approximately 30 million tons of coal were produced in this watershed in 1965. More than half of the tonnage was from the State of Ohio, and the total tonnage was about equally divided between surface and underground mining methods. Production in this area will greatly increase in the near future to supply fuel requirements of a number of steam electric generating plants which are proposed to be built along the Ohio River. (14) (17) (19) (20) (23) (25)

Streams Affected and Present Quality Pittsburgh to New Cumberland Dam

The Ohio River in this upper drainage area (1,609 square miles) is affected by mine drainage primarily due to the influence of the Monongahela River. The Ohio River at the Ohio-West Virginia-Pennsylvania state boundary carried an average net acid load of about 350 tons per day over the period 1945 to 1960. The Ohio River is presently considered to be intermittently polluted by mine drainage from its origin to the entry of the Beaver River 25 miles downstream.

In the drainage area of this reach of the Ohio River there are 195 miles of streams polluted by mine drainage. Table 20 presents the miles of streams found by this survey to be polluted by mine drainage in the Ohio River main stem and minor tributaries areas. In the upper end of the drainage area defined by the Ohio River main stem and its minor tributaries, Chartiers Creek, Montour Run, Raccoon Creek, and Sixmile Run are polluted by mine drainage (Figure 13, and Table 21). These tributaries enter the Ohio River between Pittsburgh, Pennsylvania and the Ohio state line. Chartiers and Robinson Creeks are the largest and most seriously affected of these streams.

Chartiers Creek was not an acid stream during the 1966 survey but did contain high hardness, sulfate, iron, and manganese from mine drainage discharged within its drainage area (Sta. 587). Raccoon Creek was an acid stream during the entire survey (Sta. 588). The pH ranged from 3.3 to 5.1 and the stream discharged an average net acid load of 25 tons per day to the Ohio River. Downstream at Steubenville, Ohio, Yellow Creek is affected by mine drainage over most of its length, but is not acidic (Sta. 681).

New Cumberland Dam to Belleville Dam

The middle reach of the Ohio drains an area of 3,933 square miles of Ohio, Pennsylvania, and West Virginia. Mine drainage stream pollution in this area is more severe than in the upper drainage area. Some 400 miles of streams are polluted in varying degrees by mine drainage in this watershed (Figure 14 and Table 14).

Listed in downstream order, tributary basins significantly polluted with mine drainage are: Harmon Creek (West Virginia); Cross, Short, Wheeling, McMahon, Captina, Sunfish, and Duck Creeks (Ohio). All these streams exhibit high concentrations of one or more of the constituents prevalent in mine drainage (i.e., hardness, sulfate, acidity, iron, and manganese) (Table 21).

During the 1966 survey, Harmon Creek (West Virginia) (Sta. 174) and McMahon Creek (Ohio) (Sta. 685) were consistently acid and discharged average net acid loads of 31 tons and 1.2 tons per day, respectively, to the Ohio River. The other streams sampled generally contained alkalinity in excess of acidity but discharged large iron, manganese, hardness, and sulfate loads to the Ohio River.

Tributary watersheds carrying mine drainage in smaller amounts include Kings, Cross, Buffalo, Short, and Wheeling Creeks in West Virginia and Rush Run and Little Muskingum River in Ohio. Additional drainage enters the Ohio River from active and inactive mine sites located along this reach of the Ohio River valley.

Two fish kills, resulting from acid mine drainage, were reported in this portion of the river basin during 1966.

Date	County	State	Watershed	Number of Fish Killed
a. 8/11/66	Belmont	Ohio	Captina Creek	16,591
b. 9/13/66	Carroll	Ohio	Riley's Creek	84

Belleville Dam to Meldahl Dam

The lowermost minor tributary watershed area (7,090 square miles) is more severely polluted than either of the upper tributary watersheds. This section contains more than 700 miles of streams polluted by mine drainage (Figure 15 and Table 14). The Raccoon Creek basin, which drains 684 square miles of southeastern Ohio contains 230 miles of

polluted streams and is the most severely affected tributary watershed in this reach. Nearly all of the affected streams in this area are in the state of Ohio.

The tributary basins significantly polluted with mine drainage are Shade River, Leading Creek, Raccoon Creek, Symmes Creek, and Pine Creek, Ohio (Table 21). Other affected watersheds include Campaign Creek, Indian Guyan Creek and Little Scioto River in Ohio and Twelvepole Creek in West Virginia.

Shade River (Sta. 687), and Leading Creek (Sta. 688) in Meigs County, Ohio, were sampled during the survey. These streams exhibited minimum pH readings of 4.0 and 6.7 and each discharged an average net acid load of 2.5 tons per day. Both streams were acidic through most of the survey.

Raccoon Creek enters the Ohio River near Gallipolis, Ohio, draining some of the oldest and most intensively mined areas of southeastern Ohio. Mining in this watershed began on a large scale in 1856 coincident with railroad construction. Stream surveys by the Ohio River Basin Project in 1965 and 1966 show that most of the streams in the basin are grossly polluted by mine drainage and are acid in character. Acidity concentrations as high as 424 mg/l and pH readings as low as 2.8 were recorded during these studies. Raccoon Creek carried an average net acidity load of 100 tons per day, seven miles below the mouth of Little Raccoon Creek. Little Raccoon Creek, principal tributary of Raccoon Creek, contributed an average acid load of 13 tons per day during the same period (Figure 15).

Table 20

Length of streams polluted by mine drainage upper
Ohio River main stem and minor tributaries

STREAM	DRAINAGE AREA (Sq. Mi.)	CONTINUOUSLY POLLUTED (Miles)	INTERMITTENTLY POLLUTED (Miles)	TOTAL (Miles)
Pittsburgh to New Cumberland Minor tributaries	1609	159	24	159
New Cumberland to Belleville Dam Minor tributaries	3933	365	38	403
Belleville Dam to Meldahl Dam Minor tributaries	7090	640 1,164	104 166	744 1,330

Table 21 - Water quality data, main stem Ohio River basin

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
10	6	6.9	0.0	91.0	80.0	28.0	0.0	0.0	0.0	2.9
		7.7	20.0	119.0	140.0	45.0	2.7	1.5	3.4	300.0
		7.3	6.2	100.8	116.7	35.7	0.9	0.5	1.2	99.3
11	6	6.8	0.0	21.0	35.0	10.0	0.0	0.0	0.0	1.7
		7.4	18.0	42.0	76.0	32.0	3.2	0.2	1.1	77.4
		7.0	6.8	28.7	45.2	21.3	0.8	0.1	0.4	17.8
174	7	3.8	20.0	0.0	205.0	85.0	1.3	1.5	0.0	160.0
		6.7	125.0	15.0	294.0	375.0	71.0	2.8	20.7	186.0
		5.2	70.4	5.4	246.4	233.6	32.7	2.3	6.3	175.1
175	6	6.7	0.0	26.0	747.0	150.0	0.2	1.8	0.8	0.5
		7.4	27.0	53.0	1016.0	750.0	4.8	4.1	19.0	10.0
		6.9	12.3	37.2	937.2	480.0	2.2	3.0	7.6	4.7
176	6	6.6	0.0	69.0	136.0	85.0	1.4	0.3	1.0	6.0
		7.6	25.0	138.0	1061.0	425.0	14.2	5.9	18.3	64.0
		7.0	7.0	119.0	415.8	206.0	4.1	2.2	4.8	18.9
199	4	5.3	0.0	50.0	60.0	5.0	0.5	0.2	0.0	0.0
		7.4	5.0	88.0	94.0	20.0	1.1	1.1	1.9	0.4
		6.6	1.3	61.3	71.8	13.8	0.7	0.6	0.8	0.1
200	6	6.7	0.0	52.0	65.0	14.0	0.2	0.0	0.0	0.1
		7.5	5.0	63.0	104.0	20.0	0.5	0.3	1.5	7.0
		7.1	0.8	56.8	86.2	17.8	0.3	0.2	0.6	3.9
201	6	6.7	0.0	62.0	69.0	2.0	0.5	0.3	0.0	0.1
		7.4	5.0	81.0	98.0	25.0	0.7	0.8	1.0	20.0
		7.1	1.5	68.8	81.2	15.7	0.6	0.6	0.7	3.8

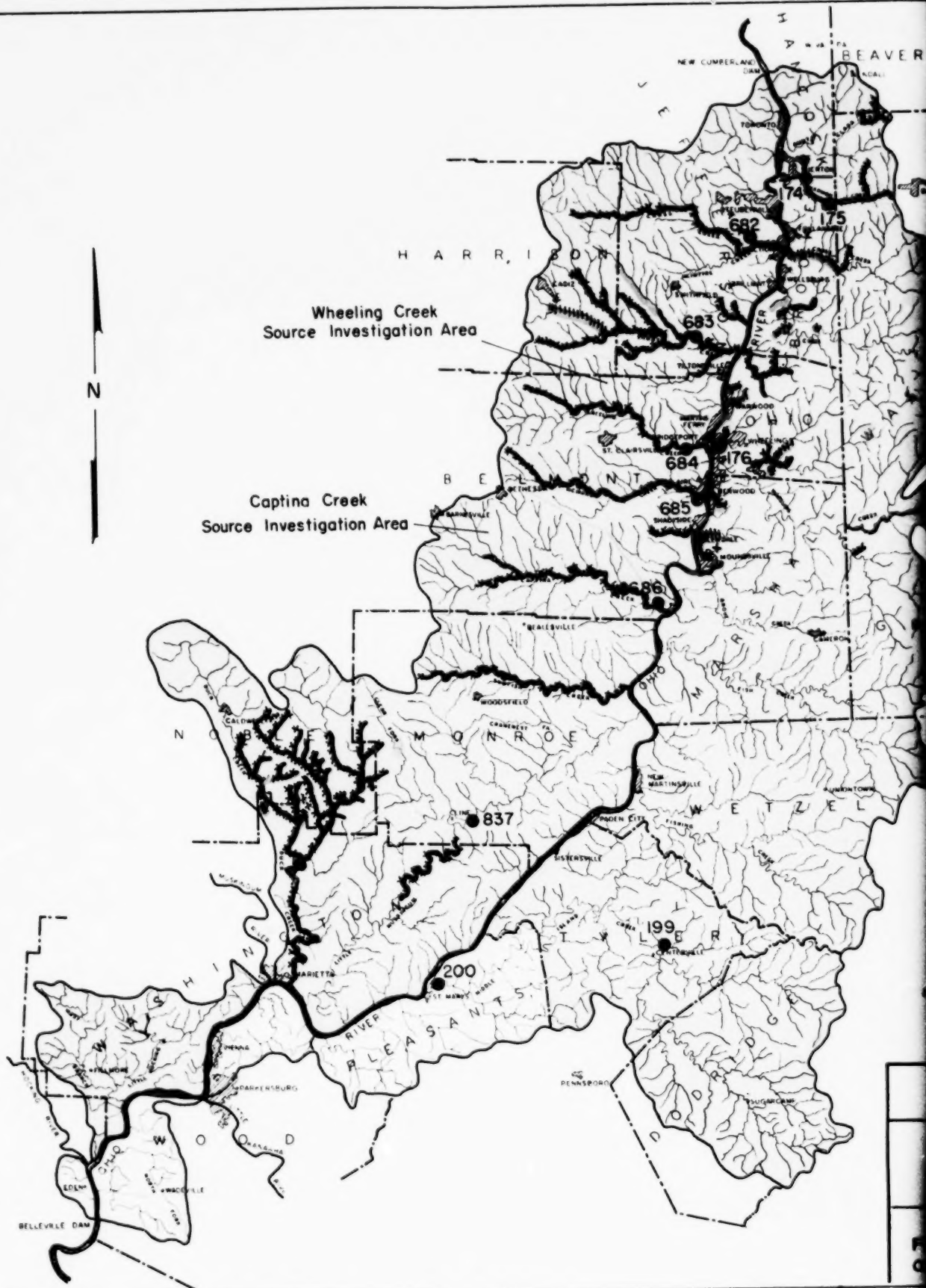
Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
202	6	7.0	0.0	35.0	46.0	12.0	0.8	0.1	0.1	0.0
		7.2	13.0	60.0	75.0	35.0	1.8	2.4	3.6	80.0
		7.1	4.7	50.7	63.0	24.2	1.6	0.9	1.5	16.0
203	6	6.8	0.0	15.0	22.0	7.0	0.8	0.2	0.9	1.0
		7.2	18.0	51.0	60.0	27.0	2.7	0.7	2.6	90.0
		7.0	9.2	33.2	44.7	17.7	1.9	0.4	1.6	20.7
587	6	6.3	5.0	18.0	522.0	400.0	2.4	2.8	5.5	62.0
		7.1	41.0	75.0	852.0	800.0	9.6	3.6	27.4	80.0
		6.6	22.3	45.2	604.2	491.7	5.7	3.2	13.6	70.8
588	6	3.3	131.0	0.0	345.0	305.0	0.1	1.1	0.0	14.0
		5.1	362.0	0.0	816.0	800.0	7.2	14.7	69.4	57.0
		4.0	244.8	0.0	627.3	463.3	3.4	8.3	27.4	34.2
681	6	6.1	1.0	7.0	262.0	185.0	0.0	0.0	0.2	9.0
		7.4	20.0	18.0	285.0	350.0	2.4	1.0	7.7	25.0
		6.8	9.2(5)*	13.2(5)	270.2	250.0	0.5	0.6	2.0	14.8
682	6	6.7	0.0	66.0	590.0	300.0	0.0	0.3	0.0	9.0
		7.5	22.0	82.0	1005.0	850.0	2.4	2.4	8.1	24.7
		7.2	6.5	73.0	820.3	510.8	0.7	1.0	2.0	15.1
683	6	6.6	0.0	110.0	920.0	30.0	1.1	0.0	4.0	24.0
		7.5	15.0	145.0	2560.0	1750.0	16.8	3.3	16.2	131.0
		7.2	5.0	127.2	1475.7	698.3	6.7	1.2	10.0	89.7
684	6	7.3	0.0	82.0	366.0	345.0	2.4	0.2	0.0	14.0
		8.0	11.0	147.0	1363.0	950.0	7.2	1.1	21.8	29.0
		7.6	2.0	121.5	1001.8	460.0	3.4	0.4	8.3	22.4

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
685	6	Min. 4.6 Max. 6.6 Avg. 5.4	Min. 0.0 Max. 125.0 Avg. 73.2	Min. 0.0 Max. 17.0 Avg. 8.0	Min. 730.0 Max. 1031.0 Avg. 877.8	Min. 15.0 Max. 450.0 Avg. 296.7	Min. 0.6 Max. 9.6 Avg. 4.6	Min. 1.0 Max. 2.0 Avg. 1.5	Min. 0.0 Max. 24.6 Avg. 11.0	Min. 3.8 Max. 9.0 Avg. 7.1
686	6	Min. 5.3 Max. 6.8 Avg. 6.4	Min. 0.0 Max. 61.0 Avg. 14.0	Min. 5.0 Max. 83.0 Avg. 48.5	Min. 295.0 Max. 381.0 Avg. 333.8	Min. 144.0 Max. 500.0 Avg. 241.2	Min. 0.5 Max. 19.2 Avg. 4.7	Min. 1.3 Max. 2.9 Avg. 1.7	Min. 1.0 Max. 4.4 Avg. 2.4	Min. 1.8 Max. 7.0 Avg. 4.2
687	6	Min. 4.0 Max. 7.1 Avg. 6.1	Min. 9.0 Max. 178.0 Avg. 56.7	Min. 0.0 Max. 45.0 Avg. 24.3	Min. 144.0 Max. 193.0 Avg. 168.7	Min. 76.0 Max. 750.0 Avg. 236.8	Min. 0.0 Max. 3.8 Avg. 1.4	Min. 0.6 Max. 7.3 Avg. 3.4	Min. 0.4 Max. 9.2 Avg. 3.6	Min. 0.1 Max. 60.0 Avg. 19.2
688	6	Min. 6.7 Max. 7.0 Avg. 6.8	Min. 15.0 Max. 37.0 Avg. 25.7	Min. 7.0 Max. 35.0 Avg. 24.7	Min. 160.0 Max. 280.0 Avg. 219.8	Min. 95.0 Max. 270.0 Avg. 193.7	Min. 0.5 Max. 4.1 Avg. 2.0	Min. 2.8 Max. 6.2 Avg. 5.0	Min. 1.0 Max. 3.6 Avg. 2.1	Min. 0.1 Max. 180.0 Avg. 35.2
700	6	Min. 6.8 Max. 7.3 Avg. 7.1	Min. 0.0 Max. 28.0 Avg. 12.3	Min. 17.0 Max. 68.0 Avg. 45.8	Min. 50.0 Max. 156.0 Avg. 121.8	Min. 62.0 Max. 85.0 Avg. 73.5	Min. 1.2 Max. 8.7 Avg. 3.0	Min. 0.6 Max. 2.8 Avg. 1.7	Min. 1.5 Max. 10.5 Avg. 4.0	Min. 8.0 Max. 320.0 Avg. 98.9
701	6	Min. 6.2 Max. 7.1 Avg. 6.9	Min. 0.0 Max. 27.0 Avg. 7.8	Min. 22.0 Max. 50.0 Avg. 31.8	Min. 40.0 Max. 82.0 Avg. 56.2	Min. 13.0 Max. 30.0 Avg. 24.5	Min. 0.6 Max. 1.8 Avg. 1.0	Min. 0.1 Max. 2.1 Avg. 0.6	Min. 0.3 Max. 2.0 Avg. 1.1	Min. 0.1 Max. 2.0 Avg. 0.6
702	6	Min. 7.2 Max. 8.0 Avg. 7.6	Min. 0.0 Max. 27.0 Avg. 7.7	Min. 91.0 Max. 210.0 Avg. 163.2	Min. 146.0 Max. 205.0 Avg. 163.8	Min. 22.0 Max. 40.0 Avg. 33.8	Min. 0.2 Max. 6.4 Avg. 1.4	Min. 0.1 Max. 3.3 Avg. 0.8	Min. 0.1 Max. 9.3 Avg. 2.4	Min. 1.3 Max. 2400.0 Avg. 413.2
703	6	Min. 7.4 Max. 8.0 Avg. 7.7	Min. 14.0 Max. 103.0 Avg. 39.5	Min. 103.0 Max. 201.0 Avg. 169.0	Min. 101.0 Max. 230.0 Avg. 161.2	Min. 28.0 Max. 40.0 Avg. 35.5	Min. 0.0 Max. 2.9 Avg. 0.7	Min. 0.2 Max. 0.7 Avg. 0.3	Min. 0.0 Max. 6.7 Avg. 1.9	Min. 0.1 Max. 17.0 Avg. 7.3
704	4	Min. 7.5 Max. 8.1 Avg. 7.8	Min. 0.0 Max. 33.0 Avg. 18.8	Min. 133.0 Max. 152.0 Avg. 141.3	Min. 98.0 Max. 190.0 Avg. 141.3	Min. 31.0 Max. 43.0 Avg. 36.8	Min. 0.1 Max. 0.5 Avg. 0.4	Min. 0.1 Max. 1.9 Avg. 0.6	Min. 0.1 Max. 0.8 Avg. 0.6	Min. 0.0 Max. 3.0 Avg. 1.3

Map Station No.	No. of Samples	pH	Acidity (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulfate (mg/l)	Total Iron (mg/l)	Manganese (mg/l)	Aluminum (mg/l)	Flow (cfs)
705	Min.	7.6	2.0	103.0	110.0	24.0	0.0	0.0	0.0	0.1
	Max.	8.6	42.0	165.0	200.0	55.0	1.0	2.8	2.5	6.0
	Avg.	8.1	18.7	130.5	160.0	43.7	0.4	0.7	1.1	3.4
706	Min.	7.4	4.0	90.0	91.0	22.0	0.1	0.0	0.5	0.1
	Max.	9.0	37.0	188.0	236.0	45.0	0.6	4.3	1.7	12.4
	Avg.	8.0	23.2	132.2	152.6	35.4	0.4	1.0	1.2	5.3
837	Min.	7.2	0.0	111.0	112.0	35.0	0.2	0.2	0.6	0.1
	Max.	7.3	9.0	111.0	156.0	35.0	0.4	0.3	0.9	0.1
	Avg.	7.3	4.5	111.0	134.0	35.0	0.3	0.3	0.8	0.1
838	Min.	7.6	0.0	20.0	140.0	105.0	0.5	0.7	0.8	13.3
	Max.	7.8	0.0	30.0	156.0	115.0	0.5	0.8	1.1	23.7
	Avg.	7.7	0.0	25.0	148.0	110.0	0.5	0.8	1.0	18.5
839	Min.	4.0	128.0	0.0	192.0	260.0	0.7	6.6	5.6	27.8
	Max.	4.2	130.0	0.0	260.0	265.0	1.0	8.8	12.0	51.0
	Avg.	4.1	129.0	0.0	226.0	262.5	0.9	7.7	8.8	39.4

*(5) Indicates the number of samples used in averages when other than the maximum.

A





VICINITY MAP

LEGEND

- STREAMS CONTINUOUSLY AFFECTED BY MINE DRAINAGE
- STREAMS INTERMITTENTLY OR POTENTIALLY AFFECTED BY MINE DRAINAGE
- APPROXIMATE AREA UNDERLAIN BY COAL-BEARING DEPOSITS
- SAMPLING STATION

SCALE
0 1 2 3 4 5 6 7 8 9 10 MILES

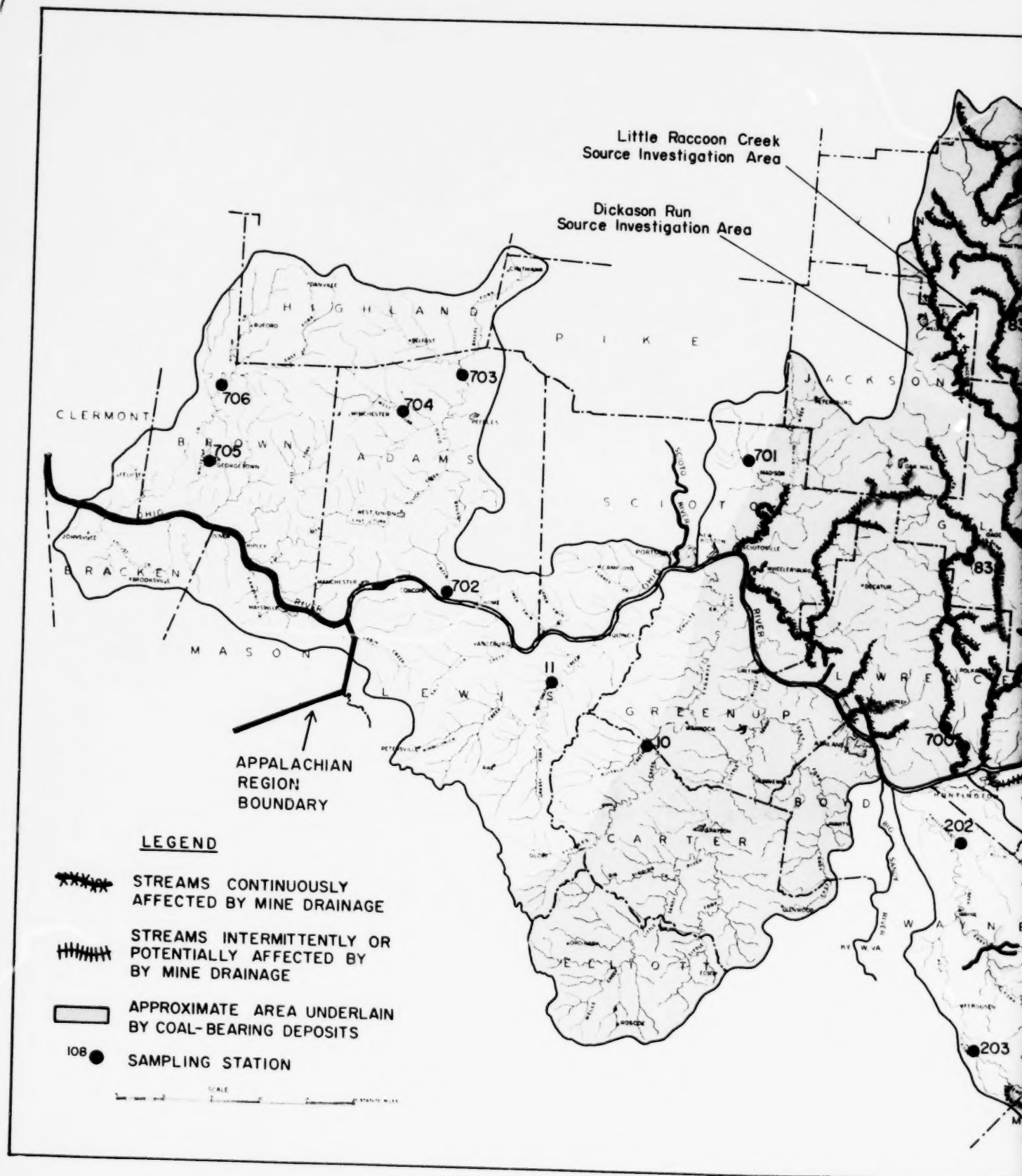
APPALACHIA MINE DRAINAGE POLLUTION REPORT

**MAIN STEM OHIO RIVER BASIN
(NEW CUMBERLAND DAM TO BELLEVILLE DAM)**

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION *101a* WHEELING FIELD STATION

FIGURE 14

A



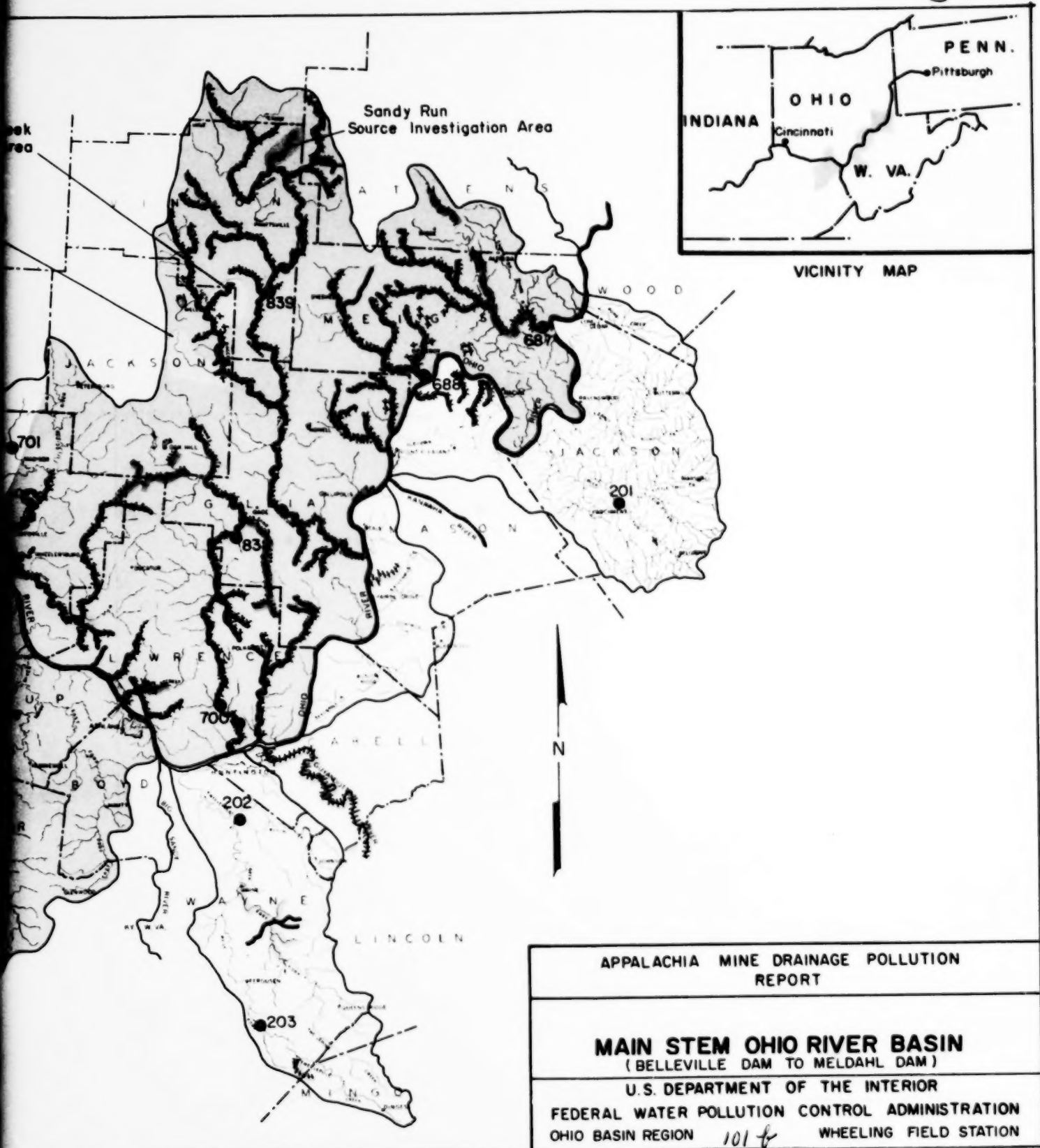


FIGURE 15

PROJECTED CONDITIONS

PRESENT MINE DRAINAGE SOURCES

Fourteen small drainage areas, scattered over the upper Ohio River basin were selected for examination and field inventory of mine drainage sources. From one to three small watersheds were selected in each of the major drainage units comprising the study area of this report. A total of 461 mine openings and affected sites were inspected in the field representing existing and potential drainage sources in a total area of about 800 square miles.

This random-sampling field survey was designed to yield statistics on the number of mine drainage sources and loading magnitudes of chemical constituents discharged to receiving streams. The watersheds and mining areas inventoried represented a wide range of geologic, topographic, mining, and pollution conditions in the states of Pennsylvania, Ohio, West Virginia and Virginia. Underground mines, surface mines, mine refuse areas, and coal preparation areas were examined in the inventory compilation.

Pertinent data for the field survey areas are listed in Table 22.

Survey Results

Quantity and quality measurements were made and loading calculations performed for each mining site discharging drainage water at the time of field inspection. The total discharge volume for the 237 sites measured totaled 9,353 gallons per minute over the 800 square mile survey area. The total acid load being discharged to the area streams from these sources equaled 52 tons per day. Eighty-six percent of the drainages were acid in character.

The discharge volumes and acid loadings are summarized in Table 23.

Based on results of the random sampling field inventory of mine drainage, it is estimated that there are about 2,600 tons per day of acid discharged to upper Ohio River basin streams from an estimated 19,000 significant abandoned or inactive coal mines (Table 24). Assuming that the total acid drainage load in the basin is equally divided between active and inactive sources, the total acid load discharged at the sources is estimated to be about 5,200 tons per day.

For purposes of this report it is assumed that water pollution problems from the operating coal mining industry will be effectively controlled by regulation at the state level. Hopefully, such effective control will be universally achieved within a few years.

Table 22

Mine drainage field survey areas

Watershed	Area* (sq. mi.)	State	Basin	Sites Examined	Drainages Sampled and Measured
Blacklegs Creek East Branch	45	Pa.	Allegheny	61	42
Clarion River	73	Pa.	Allegheny	12	12
Paint Creek	37	Pa.	Allegheny	27	11
Yellow Creek	44	Ohio	Minor Trib.	11	4
Wheeling Creek	49	Ohio	Minor Trib.	75	53
Captina Creek	180	Ohio	Minor Trib.	12	5
Raccoon Creek	57	Ohio	Minor Trib.	99	36
McLuney Creek	8	Ohio	Muskingum	22	16
Sunday Creek	74	Ohio	Hocking	20	15
Lynch Run	2.5	W.Va.	Little Kanawha	19	17
Cabin Creek	75	W.Va.	Kanawha	6	0
Heizer Creek	25	W.Va.	Kanawha	65	22
Tommy and Allen Creeks	34	W.Va.	Guyandotte	2	2
Dismal Creek	92	Va.	Big Sandy	30	2
TOTALS:	795			461	237

*In some cases less than the total watershed area of the listed drainage basin was covered in the field survey. The drainage area of the survey portion is reflected in the square mile figure.

Table 23

Mine drainage inventory summary

Watershed	Total Discharges (Gallons per minute)	Total Mine Acid Load (Tons per day)
Blacklegs Creek (Pa.)	2,209	3.4
East Branch Clarion River (Pa.)	79	1.2
Paint Creek (Pa.)	944	2.2
Yellow Creek (Ohio)	11	0.6
Wheeling Creek (Ohio)	1,096	7.4
Captina Creek (Ohio)	103	3.7
Raccoon Creek (Ohio)	137	2.0
McLuney Creek (Ohio)	2,507	24.3
Sunday Creek (Ohio)	982	2.7
Lynch Run (W. Va.)	15	0.6
Cabin Creek (W. Va.)	0	0
Heizer Creek (W. Va.)	519	3.6
Tommy and Allen Creeks (W.Va.)	750	0
Dismal Creek (Va.)	1	0
TOTALS:	9,353	51.7

Table 24

Estimated acid mine drainage from abandoned sources
upper Ohio River basin

Sub-Basin	Drainage Area	Number of Significant Mine Drainage Sources*	Acid Load Discharged to Receiving Streams (Tons/day)
Allegheny	11,730	4,000	800
Monongahela	7,380	4,000	600
Beaver	3,145	300	25
Muskingum	8,040	1,500	200
Hocking	1,200	700	100
Little Kanawha	2,310	200	5
Kanawha	12,240	1,200	175
Scioto	6,510	200	5
Guyandotte	1,680	800	50
Big Sandy	4,280	1,000	150
Minor Trib. (1)	1,610	700	50
Minor Trib. (2)	3,930	1,500	200
Minor Trib. (3)	7,090	3,000	250
TOTALS:		19,100	2,610

*The estimated number of abandoned or inactive sources discharging continuous, significant, measurable acid loads. The total number of sources including intermittent discharges, areas contributing acid only during periods of runoff, and seepage areas, is estimated to be three to four times the figures shown.

- (1) Ohio River reach from Pittsburgh, Pa. to new Cumberland Dam.
- (2) Ohio River reach from New Cumberland Dam to Belleville Dam.
- (3) Ohio River reach from Belleville Dam to Meldahl Dam.

THE FUTURE MINE DRAINAGE PROBLEM

Without the passage and implementation of effective mining and water pollution control laws and physical abatement of the residual mine drainage pollution problem, water pollution in the coal mining regions will progressively worsen. Each passing year will see increases in acid and total mineral loadings in the streams and the loss of use and productivity of additional streams and stream reaches.

Nearly a four-fold coal production increase has been projected by the year 2020 for the upper Ohio River basin. Among the principal coal producing basins, the Minor Tributaries of the Ohio River, Allegheny, and Muskingum basins are projected to show the greatest percentage increases over the projection period.

Acid load estimates have been made, based on projected production in each basin, for the years 1980, 2000, and 2020. The projections represent resultant acid loads discharged from coal production facilities, assuming no corrective measures (regulatory or physical) are applied during the projection period.

Coal production projections, by basin, are presented in Table 25. Acid loading projections are presented in Table 26.

The total acid loadings projected for the years 1980, 2000, and 2020 represent increases over the total load estimate for 1966 of about 40, 90, and 170 percent, respectively. As with projected coal production, projected acid mine drainage loadings exhibit the greatest percentage increases among the principal coal producing basins, the Minor Tributaries of the Ohio River, Allegheny, and Muskingum basins.

On a regional basis the acid component of mine drainage is the most significant and troublesome pollutant entering the basin's waters. However, the total mineralization added to stream waters by mine drainage is also quite significant to the lowering of stream water quality. Iron, manganese, and total hardness, are particularly troublesome constituents of mine drainage, in addition to acidic pH levels and total acidity content.

Suspended materials, as well as dissolved materials, are quite significant pollutant constituents emanating from coal mining and related facilities. The denudation of soil and unconsolidated materials in surface mining and the construction of mine access roads and haul roads usually makes available large quantities of silt for runoff into nearby streams.

The discharge of fine coal particles from preparation and loading facilities creates 'black water' problems in many streams. These problems are particularly acute in the Guyandotte and Big Sandy River basins.

Table 25

Coal production projections,
upper Ohio River basin*

Sub-Basin	1965 Coal Production (Million Tons)	1980 Coal Production (Million Tons)	2000 Coal Production (Million Tons)	2020 Coal Production (Million Tons)
Allegheny	26.6	56.8	98.3	143.2
Monongahela	65.8	91.2	134.7	167.0
Beaver	3.4	13.4	22.8	32.5
Main Stem	29.4	60.9	124.3	207.0
Muskingum	19.0	39.9	68.3	98.4
Hocking	0.5	10.0	25.0	40.0
Kanawha	47.3	58.0	77.2	74.6
Little Kanawha	0.1	5.0	10.0	25.0
Scioto	0.1	0.3	0.8	1.4
Big Sandy	65.0	84.4	98.6	97.5
Guyandotte	<u>30.8</u>	<u>39.0</u>	<u>53.0</u>	<u>45.0</u>
TOTALS	288.0	458.9	713.0	931.6

* Production figures are calculated from data presented in Projective.

Economic Study of the Ohio River Basin, Arthur D. Little, Inc.,
August, 1964.

Table 26

Projected acid loads from active and abandoned coal mines
upper Ohio River basin

Sub-Basin	Drainage Area	Total Acid Load Tons/Day 1966	Total Acid Load Tons/Day 1980	Total Acid Load Tons/Day 2000	Total Acid Load Tons/Day 2020
Allegheny	11,730	1,600	2,500	2,700	4,100
Monongahela	7,380	1,200	1,400	1,800	2,100
Beaver	3,145	50	120	190	250
Main Stem Minor Tributaries	12,630	1,000	1,500	2,600	4,000
Muskingum	8,040	400	610	890	1,200
Kanawha	12,300	350	410	510	560
Little Kanawha	2,310	10	30	60	130
Scioto	6,510	10	20	50	80
Big Sandy	4,280	300	340	370	370
Guyandotte	1,680	100	120	140	130
Hocking	1,200	200	390	690	990
TOTALS	71,205	5,220	7,440	10,000	13,910

ESTIMATED ABATEMENT COSTS

Estimated costs of acid mine drainage abatement in tributary drainage areas of the upper Ohio River basin are shown in Table 27.

The present total acid load in tons per day given in the table is the total of both active and inactive or abandoned mining operations. It is estimated that 50 percent of the present total acid load is being discharged from active mining operations. If adequate regulatory measures are enacted and properly implemented, it is assumed that practically all of the acid load contribution from these operations will be eliminated.

It is estimated that 25 percent of the total acid load from inactive workings is from old strip and surface mining areas. Known methods of land restoration executed on such lands will effectively abate pollution from this source. The cost estimates for this abatement category are based on complete restoration costs ranging from \$1000 to \$3000 per acre.

An estimated 75 percent of the acid load from non-operating mines is from underground sources. Although methods of reducing the load from these sources are yet to be fully evaluated, it is estimated that half of this contribution can be reduced by mine sealing and/or related construction programs. A cost range of \$2,000 to \$10,000 per deep-mine pollution source was used in the cost estimation.

The listed remedial abatement program costs in the various basins are for physical corrective measures only and do not include funds for the development of total abatement programs that would include field inventory and engineering study phases. The total abatement program would also necessarily include an annual cost for inspection and maintenance of physical structures.

The total residual acid load after completion of the regulatory correction and remedial abatement phases of the program, estimated at nearly 1000 tons per day, represents an overall reduction of 80 percent of the original pollution load (See Figure 16). If this reduction magnitude is achieved, it is expected that the basin's streams will be able to assimilate the residual loads without any significant quality disturbance. Where exceptions occur, on-stream treatment facilities may be the only means to return the streams to a reasonable quality level.

Table 27

Estimated costs of acid mine drainage abatement program
upper Ohio River basin

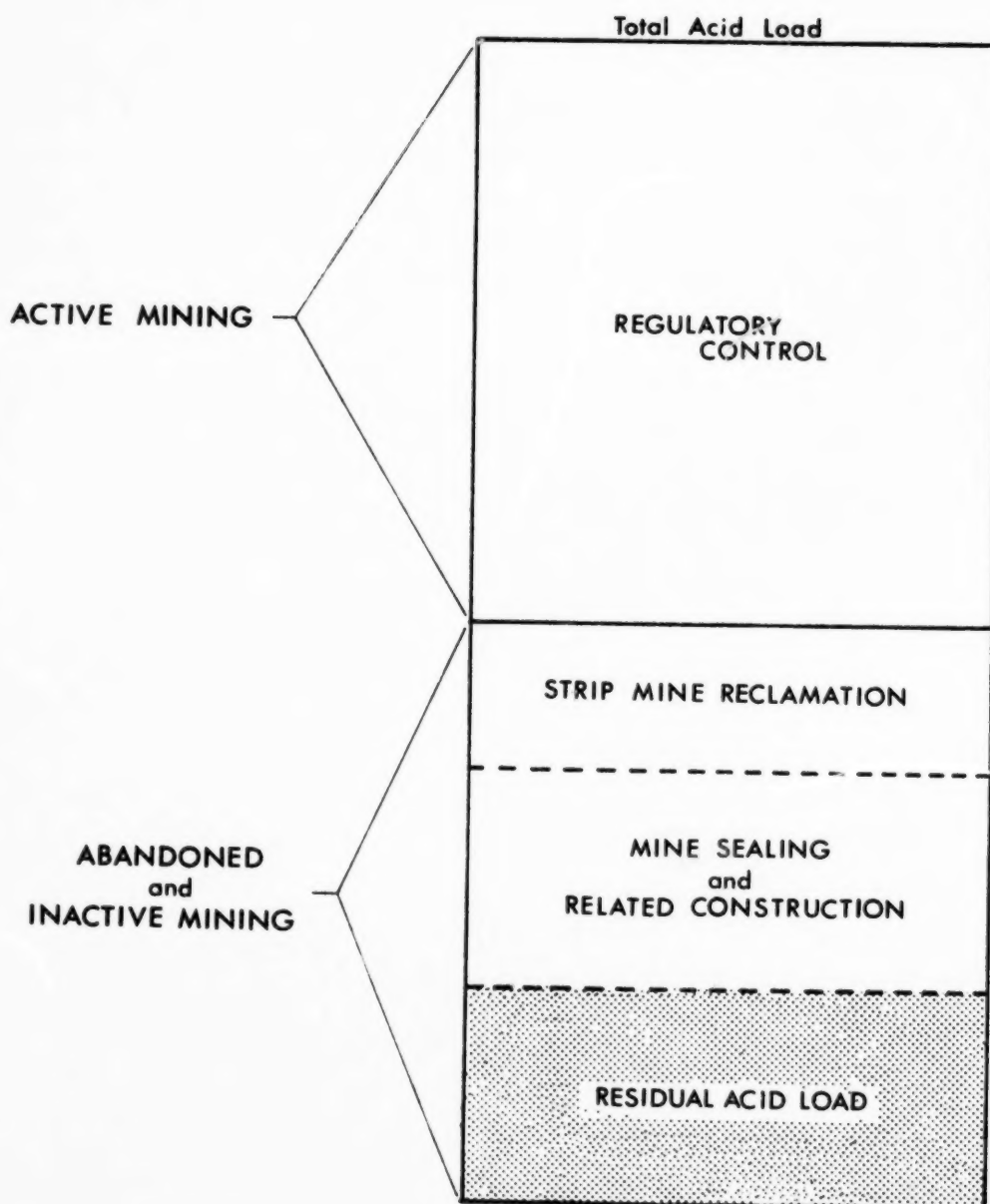
upper Ohio river basin										
Basin	Acres of Unreclaimed Strip Mines 1/	No. of Significant Pollution Sources 2/	Regulatory Correction by					Remedial Abatement Programs		Remedial Abatement Program Costs 2/ (Millions of Dollars)
			Present Total Acid Load Tons/Day 2/	State Agencies (Active Mining) Acid Load Reduction Tons/Day	Strip Mine Reclamation Acid Load Reduction Tons/Day	Mine Sealing & Related Construction Acid Load Reduction Tons/Day	Residual Acid Load Tons/Day			
Allegheny	79,000	4,000	1,600	800	200.0	300.0	300.0	300.0	184.0	184.0
Monongahela	79,000	4,000	1,200	600	150.0	225.0	225.0	225.0	184.0	184.0
Beaver	20,000	300	50	25	6.3	9.4	9.4	9.3	40.7	40.7
Main Stem	48,000	5,200	1,000	500	125.0	187.5	187.5	187.5	125.9	125.9
Maskingus	29,000	1,500	400	200	50.0	75.0	75.0	75.0	65.5	65.5
Kanawha	64,000	1,200	350	175	43.8	65.6	65.6	65.6	133.8	133.8
Little Kanawha	4,000	200	10	5	1.3	1.9	1.9	1.8	8.4	8.4
Scioto	1,000	200	10	5	1.3	1.9	1.9	1.8	3.3	3.3
Big Sandy	31,000	1,000	300	150	37.5	56.3	56.3	56.2	67.9	67.9
Ouyendotte	11,000	800	100	50	12.5	18.8	18.8	18.7	25.9	25.9
Hocking	4,000	700	200	100	25.0	37.5	37.5	37.5	11.4	11.4
Totals	370,000	19,100	5,220	2,610	652.7	978.9	978.9	987.4	850.8	850.8

1/ Totally unreclaimed acreage plus partially reclaimed acreage.

2/ From Table 24.

3/ Costs are for physical abatement measures only; exclusive of engineering study, maintenance, and other program development costs.

ACID MINE DRAINAGE ABATEMENT UPPER OHIO RIVER BASIN



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